CALIFORNIA FISH AND GAME

"CONSERVATION OF WILD LIFE THROUGH EDUCATION"

VOLUME 38 JANUARY, 1952 NUMBER 1

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A NEW FISH AND GAME ERA

Man's social progress has, for convenience, been divided into defined eras or epochs, each covering an important stage of his long climb up the ladder of our modern civilization. The history of wildlife restoration and management likewise divides itself into similar periods of recorded progress.

September 22, 1951, marks the beginning of another step in California's century-old effort to perpetuate the vast fish and game resources of this great State. On that date the Charles Brown Fish and Game Reorganization Act of 1951, Chapter 715, became operative, and California's new Department of Fish and Game began to function. A supplement thereto, Chapter 1323, clarifies the respective duties of the Fish and Game Commission and the administrator, designated as the director.

The reorganization act transferred to the new department all of the operations, functions, property, etc., of the former Division of Fish and Game from the Department of Natural Resources, of which it had been an integral part since 1927.

The act stipulates that the new department shall be administered in accordance with the policies and programs established by the Fish and Game Commission. The director, who is in entire charge of all personnel and administrative functions, is appointed by the Governor. He is a member of the Governor's Council and serves at his pleasure.

What does it all mean? In the simplest possible language, it is merely the fruition of a long-delayed recognition of the increasing importance of angling, hunting, and commercial fishing to the welfare and economy of California, and to her 11,000,000 citizens. Further, it is an attempt to centralize administrative responsibility, in the hope of eliminating many of the past difficulties.

Does the new law materially change the basic functions of the Fish and Game Commission? No, it does not. The commission still has all of the essential responsibilities it had previously, but it is relieved of the worries involved in administrative operations. It is still responsible for all general policy-making and regulatory functions.

Will the new plan assure greater accomplishments for the dollars spent? While fish and game management is normally beset with more headaches than other public functions, the new law, if given a fair trial, should accomplish the aims of its sponsors. Better coordination and the elimination of confusion should definitely assure more value for every dollar spent. Much will depend upon the extent to which all concerned, officials, departmental personnel, sportsmen, commercial fishermen, and the general public, succeed in developing a high spirit of teamwork and cooperation.

Among the previous prominent milestones in California's fish and game history are the first game law in 1852, two years after admission to the Union; creation of the original Fish Commission, the forerunner of the present department, 1870, a year before the Federal Government set up such an agency; court affirmation of the people's ownership of fish and game, 1894; the Hunting License Law of 1907 and the Fishing License Law of 1913 to provide funds; the establishment of the five-man Fish and Game Commission, with staggered terms, by constitutional amendment in 1940; prohibiting the diversion of fish and game funds, by constitutional amendment in 1942; the delegation of regulatory powers to the Fish and Game Commission to fix seasons, bag limits, etc., as is done in most of the states, 1945; and the Wildlife Conservation Act of 1947, to provide supplemental funds for a long-neglected capital investment program to improve fish and game conditions, a $12,000,000 venture to date.

We now have a Fish and Game Department with an annual budget of $6,000,000, none of which comes from general taxpayer contributions. We have close to 800 excellent employees, the largest state fish and game agency in the United States.

This new pattern of fish and game administration is novel, and largely untried. If it succeeds, other states will quickly adopt it. If it fails, something better will replace it. Future historians must evaluate the results.

Yes, notwithstanding the problems of the past, California's fish and game history is a notable one. We of the department, and the people of California, cannot let the new venture fail. Each of us must help make the new epoch a rousing success.

Seth Gordon

Director

BAIT FISHES OF THE LOWER COLORADO RIVER FROM LAKE MEAD, NEVADA, TO YUMA, ARIZONA, WITH A KEY FOR THEIR IDENTIFICATION[1]

By ROBERT RUSH MILLER
Museum of Zoology, University of Michigan

INTRODUCTION

Transformation of the unpredictable, silt-laden, lower Colorado River into the placid blue waters which now characterize its course for long stretches, has brought with it unforseen problems in biological management. One of these problems concerns the bait needs of the thousands of fishermen who yearly seek the recreation afforded by the river and its artificial lakes. Such major introductions as the rainbow trout (*Salmo gairdneri*), channel catfish (*Ictalurus punctatus*),[2] largemouth black bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*), have created a fishing intensity which the lower Colorado River has never experienced heretofore. Few, if any, of the multitude of fishing enthusiasts who purchase bait fishes are aware of the possibility that the escape of some species could, with establishment in the river, do major damage to the fishery. Indeed, it is only the unusual individual who observes that bait dealers offer more than a single species for sale. Neither are most bait dealers cognizant of the fact that the introduction of exotic species into the Colorado might lead to the serious curtailment or elimination of their business through a decline in the fishery.

A major purpose of this article, therefore, is to distinguish between the species of bait fishes that are being (or have been) utilized along the river, from Lake Mead to Yuma, and to make it possible for bait dealers, interested fishermen, fishery biologists, and wardens to identify most of the species that are being sold. Nearly all of the species are illustrated by a line drawing and each is further identified by means of an artificial "key," which provides a rapid index to the distinctive characters of each kind. The known or probable origin of the species is given, along with a considered judgment as to whether its establishment in the river will cause damage to the fishery. The natural distribution and general habitat requirements of each bait fish are also presented, insofar as they are known. Some of the bait fishes listed below (such as the carp, mosquitofish, bluegill, and green sunfish) are already a part of the river fauna, but, with the possible exception of the Utah chub (*Gila atraria*) and the Bonneville mottled sculpin (*Cottus bairdi semiscaber*), none of the others has become established so far as known at present (May 1, 1951).

[1] Submitted for publication May, 1951. The field work was financed through a research grant from the Horace H. Rackham School of Graduate Studies, University of Michigan. Common names employed herein are those officially adopted by the California Department of Fish and Game and are not necessarily the choice of the author.

[2] It has been found that *I. lacustris* is synonymous with *Lota lota*. See article by J. Murray Speirs in Copeia (in press).

ACKNOWLEDGMENTS

In the preparation of this article, I have been favored with splendid cooperation from many sources, and without this help the following presentation would have been inadequate. Members of the University of California at Los Angeles, the Scripps Institution of Oceanography (University of California) at La Jolla, and the California Department of Fish and Game actively participated in the field work in the spring of 1950. Intermittent sampling of bait tanks has been continued since then, chiefly by the California Department of Fish and Game, with the result that additional bait species have been discovered along with new data on sources of supply. Carl L. Hubbs has collaborated in identifying the bait fishes and has offered valuable advice during the preparation of the manuscript. I am grateful to William L. Brudon, staff artist of the Museum of Zoology, University of Michigan, who prepared the line drawings.

Bait collectors, especially Milt Holt, have supplied valuable information and bait distributors likewise have volunteered useful data. All of the following individuals have cooperated in various ways: Clarence G. Alexander, Al A. Allanson, Fred Baumiller, Richard D. Beland, Bob Bolam, Delbert Coombs, Philip A. Douglas, Willis A. Evans, Arthur Flechsig, Russell K. Grater, Luis Guzman, Milt Holt, Al Jonez, Tommy Kinder, Tim Murphy, Sidney Peritz, Leo Rossier, George Savard, Vic Spratt, Boyd W. Walker, Kirby H. Walker, O. L. Wallis, Bob Williams, Howard E. Winn, Donald E. Wohlschlag, and A. W. Yoder.

The "Colorado River Fishing-Hunting Atlas" contains an excellent set of maps that show some of the best hunting and fishing spots, roads and towns, places mentioned in this article, and other points of interest from Lake Mead to Yuma. This is a valuable guide for anyone interested in this section of the Colorado River, and may be purchased along the river or from C. E. Erickson and Associates, Berkeley 9, California, for 50 cents. An excellent source of information on bait fishes is the illustrated booklet entitled "Propagation of Minnows and other Bait Species," published in 1948 as Circular 12 of the United States Fish and Wildlife Service; it is available from the Superintendent of Documents, Washington 25, D. C., for 35 cents.

AN ILLUSTRATED KEY TO THE BAIT FISHES OF THE LOWER COLORADO RIVER

In the dichotomous key that follows, the reader has two alternatives (a and b) to choose at a time and, having made a choice, he then chooses again between two sets of opposed characters, and continues until the name of a species is reached. The contrasting characters for each pair are always indicated by the same number, for example 2a and 2b; please read both of the opposed characters before reaching a decision as to which one to follow. Technicalities have been purposefully reduced to a minimum in this simplified key, and it is hoped that most users of the key will be able to identify their specimens largely from the drawings.

It should be possible, with practice, to recognize most of the 32 species keyed out below. However, the identity of some of the species of suckers (particularly the mountain-suckers of the genus *Pantosteus*) is difficult

to determine even for the expert, and a workable key to such species is hardly practical. Thus certain portions of this key (particularly items 15a to 17b) are presented with the realization that they will not work for every specimen. The scale on each drawing represents one inch.

1a. A small, fleshy fin (the adipose fin) on the back just in front of the caudal (tail) fin. Teeth in jaws large and sharp____ Mexican banded tetra, *Astyanax fasciatus mexicanus*

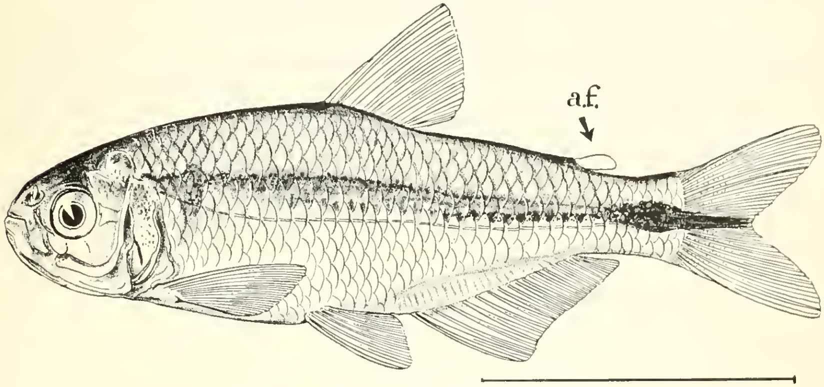

FIGURE 1. Mexican banded tetra

1b. No adipose fin. Teeth in jaws small or absent.

2a. Pelvic (belly) fins attached to abdomen below pectoral (breast) fins. Dorsal fin comprising two parts, a spinous and a soft portion, which are either united or separate. (The spinous part may be only feebly spine-like.)

3a. Body without scales but typically with a small patch of prickles on each side behind pectoral fins_____Bonneville mottled sculpin, *Cottus bairdi semiscaber*

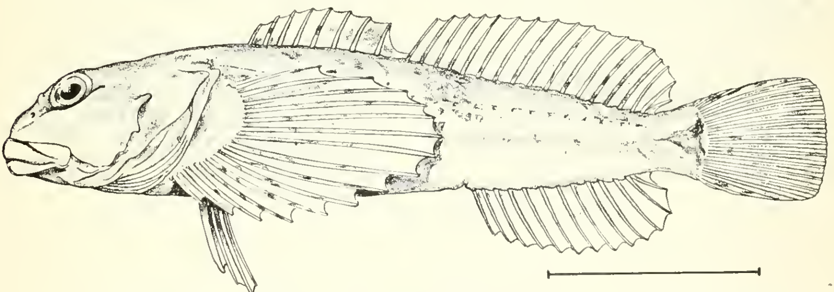

FIGURE 2. Bonneville mottled sculpin

3b. Body covered with scales (very small in the mudsuckers).

4a. Body long and slender, the tail rounded. Jaws extremely long, extending backward nearly to end of head (mudsuckers, genus *Gillichthys*[3]).

5a. Pectoral fin rays (all rays counted) usually 19 to 21, infrequently 18 or 22 ____ Longjaw mudsucker, *Gillichthys mirabilis*

5b. Pectoral rays usually 22 to 23, sometimes 21 or 24 ____ Gulf mudsucker, *Gillichthys detrusus*

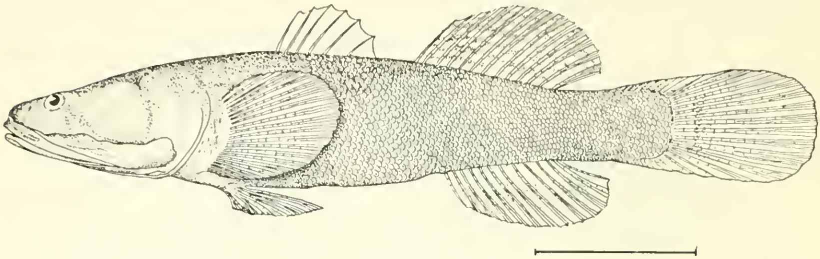

FIGURE 3. Gulf mudsucker (after Gilbert and Scofield)

4b. Body moderately slender to deep, the tail forked. Jaws normal, not extending beyond eye.

6a. Dorsal fin made up of two separate parts. Body crossed by prominent, dark vertical bands. Two spines in anal fin ____ Yellow perch, *Perca flavescens*

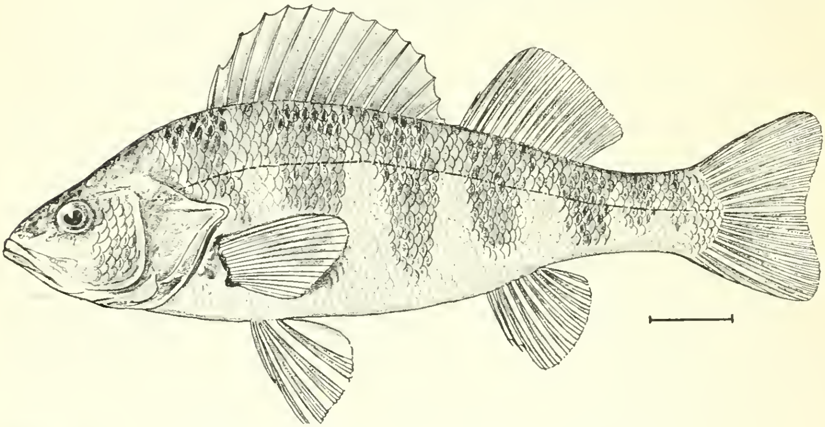

FIGURE 4. Yellow perch (after Forbes and Richardson)

[3] The key to the two species of *Gillichthys* is taken directly from a manuscript by Isaac Ginsburg, through his kind permission. See text for status of *G. detrusus* in California.

6b. Dorsal fin single. Body with less marked bands, often indistinct or absent. Three spines in anal fin (sunfishes, genus *Lepomis*).

7a. Mouth larger, upper jaw extending to below middle of eye. Pectoral fins short and rounded, their length entering about 4 times in distance from tip of snout to base of tail fin ___ Green sunfish, *Lepomis cyanellus*

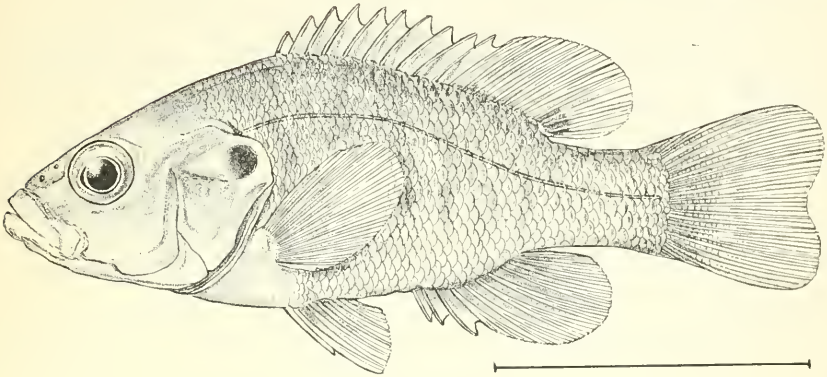

FIGURE 5. Green sunfish

7b. Mouth smaller, upper jaw not extending back as far as anterior margin of eye. Pectoral fins long and pointed, their length contained about 3 times in distance from tip of snout to base of tail fin ______________ Bluegill, *Lepomis macrochirus*

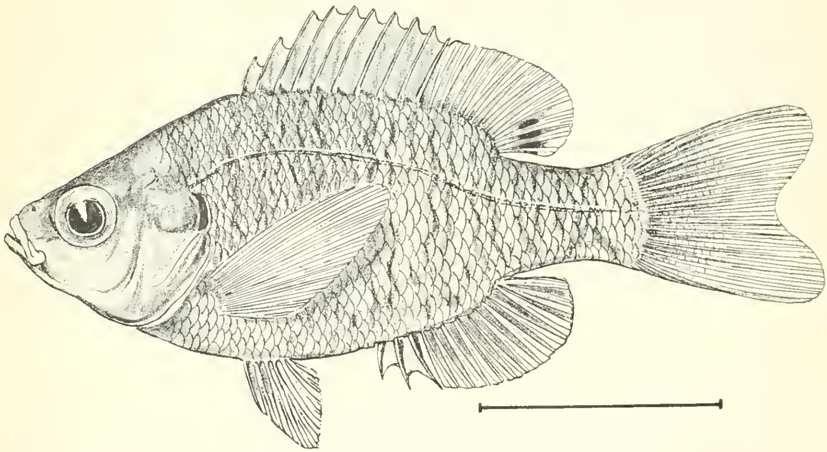

FIGURE 6. Bluegill

2b. Pelvic fins attached to abdomen well behind pectoral fins, usually nearly below origin of dorsal fin. A single, soft-rayed [4] dorsal fin.

8a. Head covered with scales. Dorsal and anal fins about equal in size, the origin of the dorsal slightly before, to well behind, that of the anal. Small teeth in jaws.

9a. Dorsal fin small, typically with only 6 rays (including first small ray and last two counted as one), its origin well behind that of anal fin. Anal fin of mature male modified into a spike-like reproductive organ .... Western mosquitofish, *Gambusia affinis affinis*

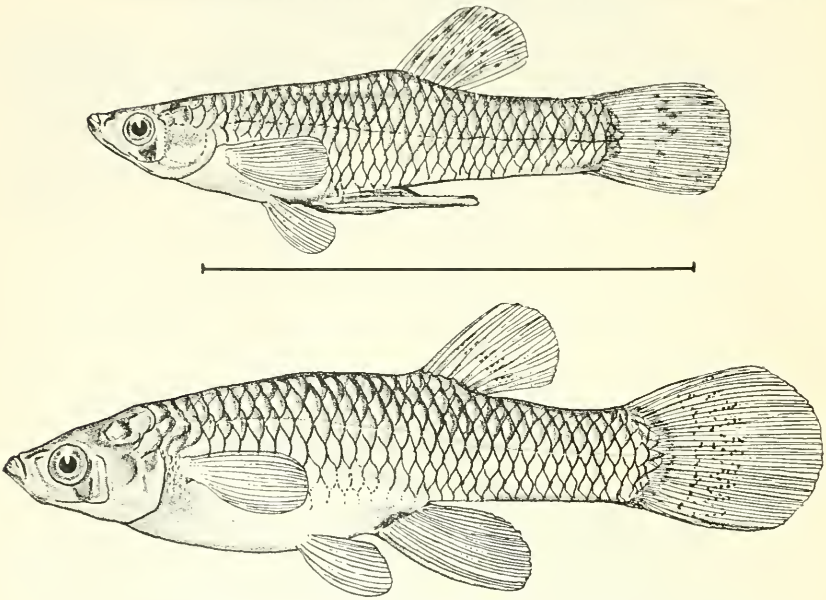

FIGURE 7. Western masquitofish, male (above) and female

9b. Dorsal fin much larger, with 12 or more rays, its origin over or slightly in front of that of anal. Anal fin of male not modified into a spike-like organ.

10a. Sides of body with a weak lateral band that tends to form irregular spots and incomplete vertical bars posteriorly. Scales in lateral series (from end of head to base of tail) fewer than 40............ Southern California killifish, *Fundulus parvipinnis parvipinnis*

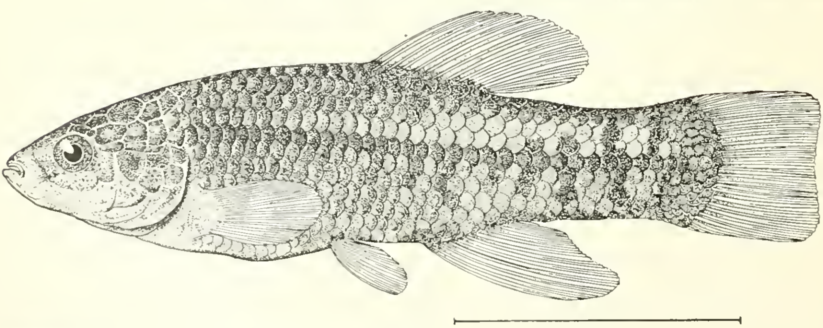

FIGURE 8. Southern California killifish (male)

[4] With a serrated spine in the carp and goldfish, or 2 smooth spines in *Plagopterus* and *Lepidomeda*. See items 19a and 19b.

10b. Sides of body crossed by numerous vertical bars, broader and more conspicuous in males than in females. Scales in lateral series more than 40 .... Southwestern Plains killifish, *Fundulus zebrinus*

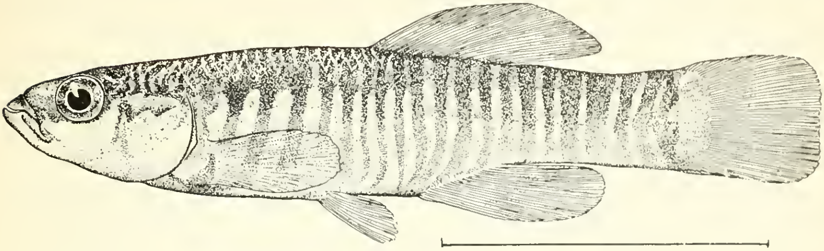

FIGURE 9. Southwestern Ploins killifish (male)

8b. Head scaleless. Dorsal and anal fins typically unequal in size, the origin of the dorsal always well in advance of that of the anal. No teeth in jaws.

11a. Mouth on lower side of head, with thick fleshy lips. Caudal rays 18, 16 branched (suckers, family Catostomidae).

12a. No distinct notch (see Fig. 14B) at corner of mouth between upper and lower lips. Upper lip nearly flat, covered with small papillae. Lower lip with a deep, median notch (genus *Catostomus*).

13a. Dorsal and caudal fins very large, the dorsal with a sickle-shaped margin. Caudal peduncle (base of tail) pencil-shaped. Scales very small, 89 to 112 along lateral line .... Flannelmouth sucker, *Catostomus latipinnis*

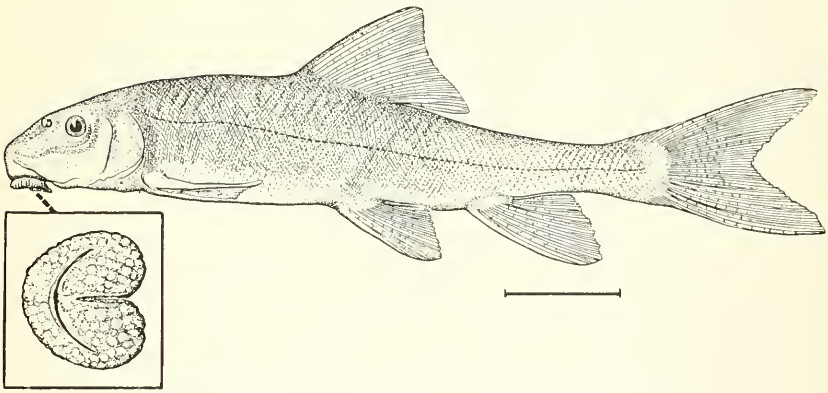

FIGURE 10. Flannelmouth sucker. Inset shows ventral view of mouth.

13b. Dorsal and caudal fins not notably enlarged, the dorsal not sickle-shaped. Caudal peduncle not pencil-shaped. Scales large, 55 to 70 along lateral line.

14a. Mandible (lower jaw) short, its length contained 3.5 or more times in the head length. Upper lip narrow____________ Western white sucker, *Catostomus commersoni suckleyi*

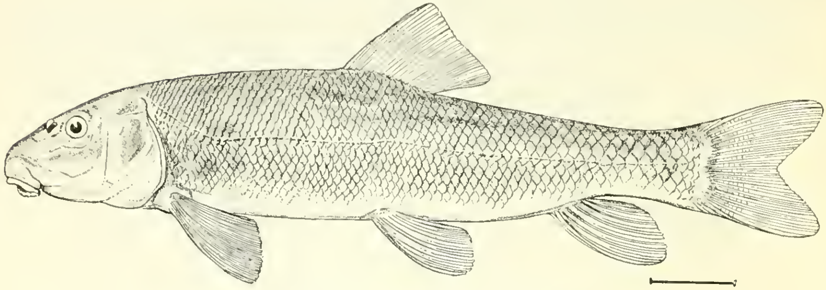

FIGURE 11. Western white sucker

14b. Mandible long, its length contained 3.3 or less times in the head length. Upper lip broad____________ Utah sucker, *Catostomus ardens*

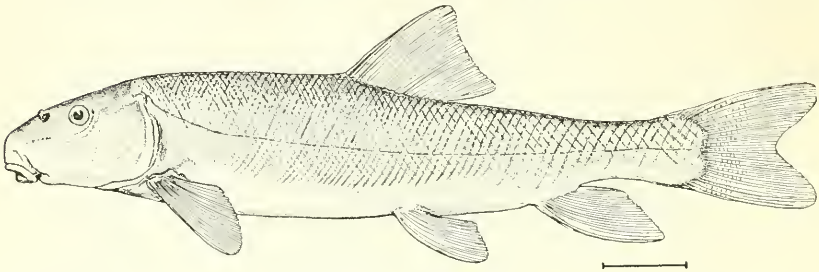

FIGURE 12. Utah sucker

12b. A distinct notch (Figure 14B) at corner of mouth between upper and lower lips. Upper lip recurved, smooth. Lower lip with a shallow, median notch [5] (genus *Pantosteus*).

15a. Fontanelle on top of skull (Figure 14A, C) typically open (exposed by scraping away skin and membranous cover).

16a. Pigment on sides extending below base of pectoral fin and onto lower surface of head____________ Dusky mountain-sucker, *Pantosteus* species

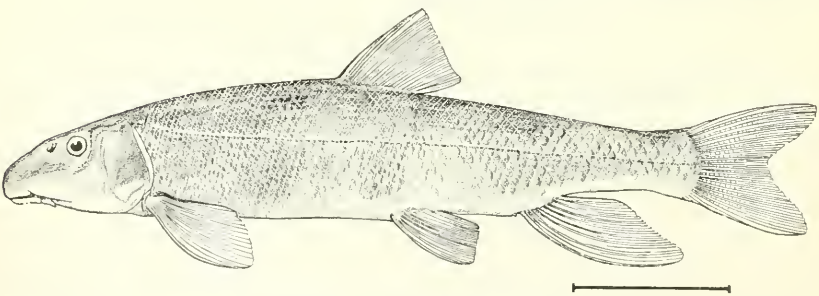

FIGURE 13. Dusky mountain-sucker

[5] Except in *Pantosteus plebeius* in which it is deeper than usual for the genus.

16b. Pigment on sides not extending below a horizontal line well above pectoral base; none on lower surface of head
Bonneville mountain-sucker, *Pantosteus platyrhynchus*

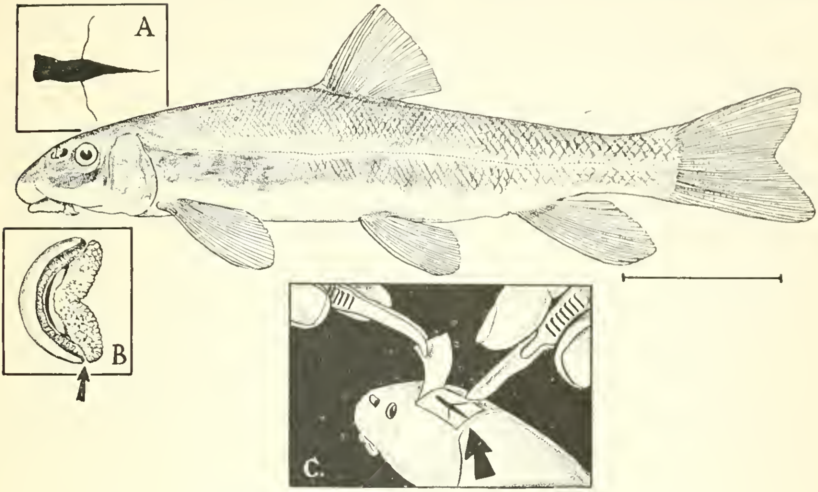

FIGURE 14. Bonneville mountin-sucker. Inset A shows open fontanelle; B, notch at lip corners; and C, method of exposing fontanelle.

15b. Fontanelle typically closed (Figure 15).

17a. Dorsal rays usually 10 (rarely 9, occasionally 11; count includes only principal rays). Snout more bulbous, conspicuously overhanging the mouth. Cartilaginous sheaths on jaws well developed; median incision of lower lip shallow.

18a. Scales larger, about 75 to 95 in lateral line. Caudal peduncle deeper, its least depth about 2.7 to 3.1 times in head length Utah bluehead mountain-sucker, *Pantosteus delphinus utahensis*

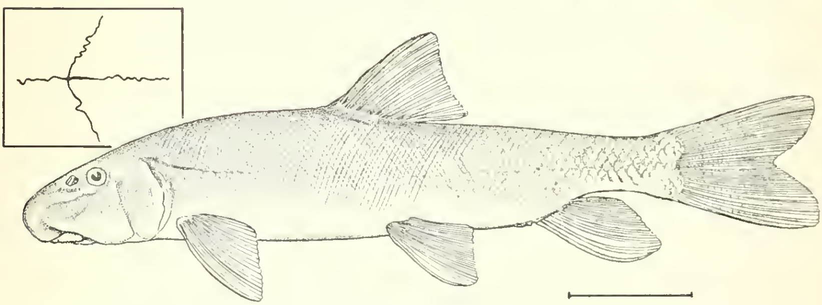

FIGURE 15. Utah bluehead mountain-sucker. Inset shows closed fontanelle.

18b. Scales smaller, about 96 to 118 in lateral line. Caudal peduncle slenderer, its least depth about 3.0 to 3.5 times in head length ________________________ Northern bluehead mountain-sucker, *Pantosteus delphinus delphinus*

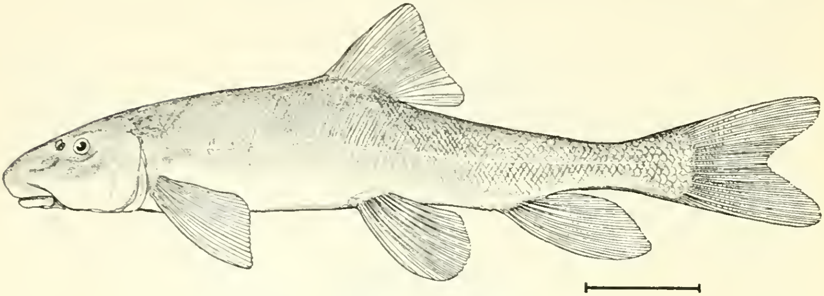

FIGURE 16. Northern bluehead mountain-sucker

17b. Dorsal rays usually 9 (occasionally 10). Snout slightly bulbous, hardly overhanging the mouth. Cartilaginous sheaths on jaws weak; median incision of lower lip rather deep________ ___________Río Grande mountain-sucker, *Pantosteus plebeius*

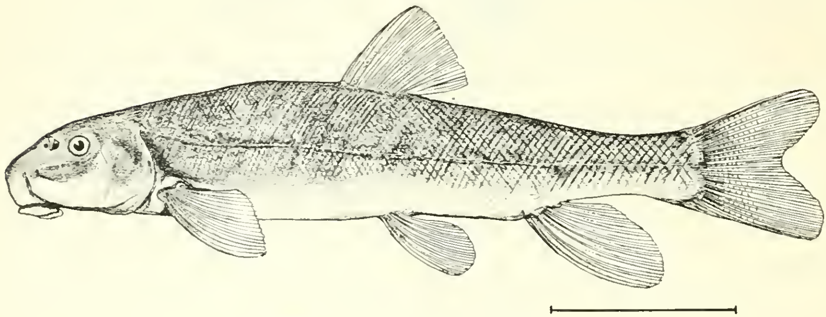

FIGURE 17. Rio Grande mountain-sucker

11b. Mouth terminal or subterminal, not on lower side of head, the lips not thick and fleshy. Caudal rays 19, 17 branched (minnows, family Cyprinidae).

19a. Dorsal and anal fins each with a saw-edged, hard spine (rather inconspicuous in the young). Dorsal fin long, with more than 15 soft rays (branched rays plus one, the last two counted as one ray).

20a. Upper jaw with 2 fleshy barbels ("whiskers") on each side. Scales in lateral line 35 to 38, sometimes scaleless ("leather" carp) or partially scaled ("mirror" carp). (Total gill rakers on first arch 21 to 27; pharyngeal teeth in 3 rows on each arch.) ---------- Carp, *Cyprinus carpio*

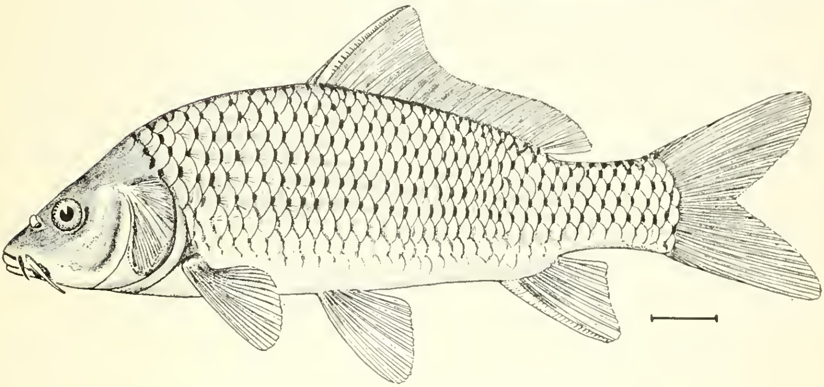

FIGURE 18. Carp (after Forbes and Richardson)

20b. Upper jaw without barbels. Scales in lateral line 26 to 29. (Total gill rakers 37 to 43; pharyngeal teeth in a single row.) ---------- Goldfish, *Carassius auratus*

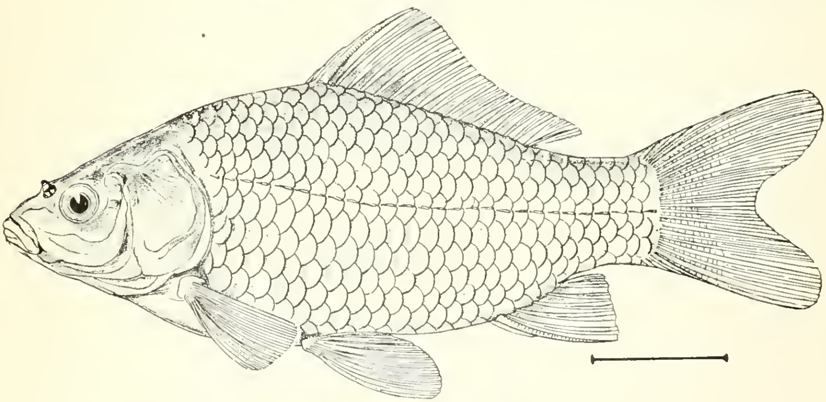

FIGURE 19. Goldfish

19b. Dorsal and anal fins without heavy, toothed spines, the dorsal fin with 2 smooth spines or none at all. Dorsal short, with 13 or fewer rays.

21a. First two dorsal rays modified as smooth spines, the anterior one with a groove on its posterior side into which the second fits. Inner border of pelvic fins attached to body by membrane, the pelvic rays spine-like (at least in part).

22a. First dorsal spine long and sharp. Body slender, elongate, its color like burnished silver. No scales. Eye small ---------- Woundfin, *Plagopterus argentissimus*

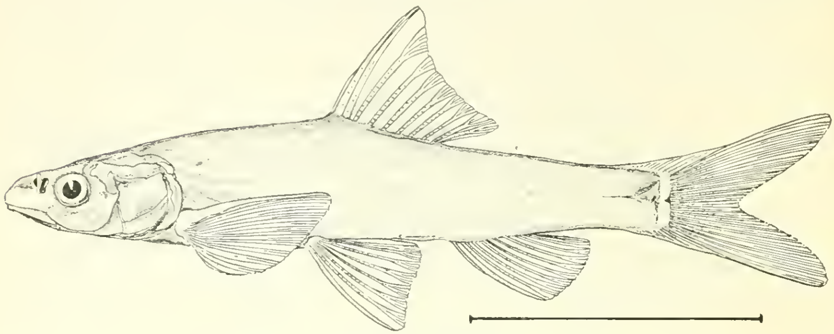

FIGURE 20. Woundfin

22b. First dorsal spine short, not sharp at tip. Body heavier and not bright silvery all over. Scales present except just behind pectoral fins. Eye large.

23a. Length of mandible (lower jaw) enters distance between origin of dorsal fin and tip of snout 4.6 to 4.9 times. Sides of body mostly silvery, somewhat mottled, with only scattered pigment below level of lateral line---------- Virgin River spine-dace, *Lepidomeda* species

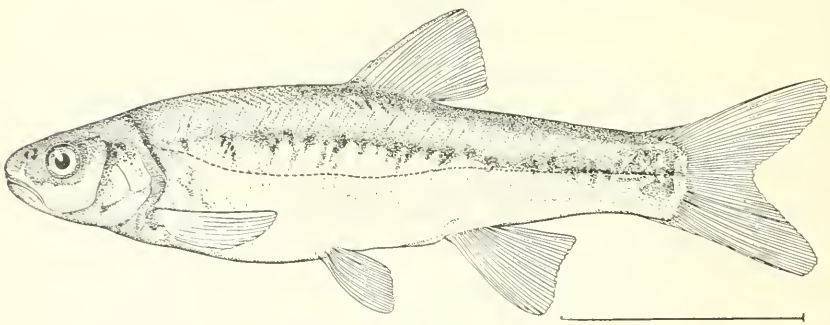

FIGURE 21. Virgin River spine-dace

23b. Length of mandible 4.1 to 4.6 times in distance from dorsal origin to tip of snout. Sides of body darker, with a strong tendency to form a dark lateral band, the pigment extending well below level of lateral line
White River spine-dace, *Lepidomeda* species

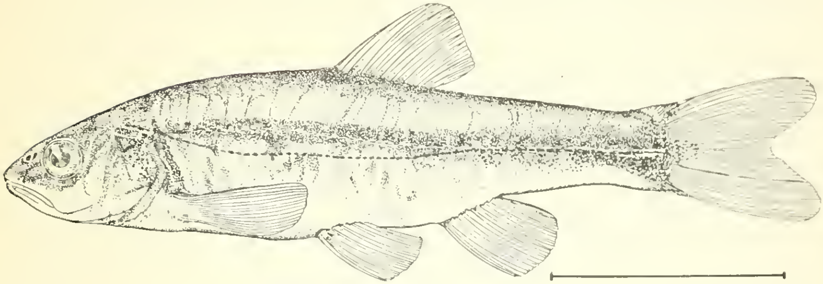

FIGURE 22. White River spine-dace

21b. Dorsal fin without spine-like rays. Inner border of pelvic fins not attached to body, the pelvic rays nowhere spine-like.

24a. Anal fin large, usually with 10 to 15 rays, the fin margin sickle-shaped. Origin of dorsal fin well behind that of pelvics. Lateral line notably decurved, running much nearer ventral profile than back.

25a. A fleshy keel on abdomen between pelvic and anal fins, over which the scales do not pass. Dorsal rays 8
Golden shiner, *Notemigonus crysoleucas*

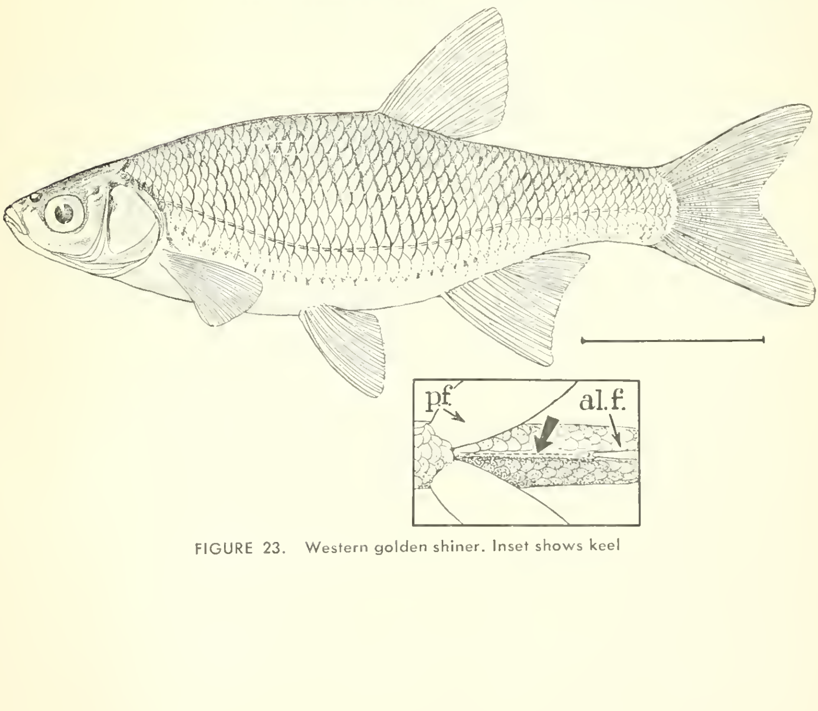

FIGURE 23. Western golden shiner. Inset shows keel

25b. No fleshy keel on abdomen. Dorsal rays 9 to 12.

26a. Mouth short, not extending backwards much beyond nostrils. No pink or red band in life. (Dorsal 10 to 12, teeth 5-5, gill rakers 17 to 26.) ---------- Sacramento hitch, *Lavinia exilicauda exilicauda*

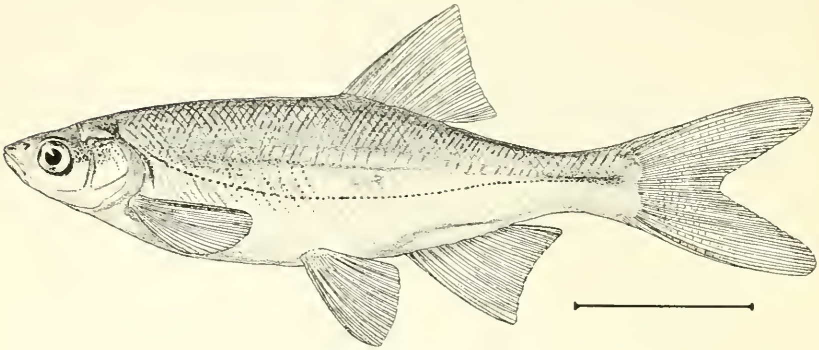

FIGURE 24. Sacramento hitch

26b. Mouth long, extending backward to or beyond anterior margin of eye. A pink or red band on side in both sexes, especially prominent on males in breeding season. (Dorsal 9 to 11, teeth 2, 5-4, 2, gill rakers 6 to 9.) -------- Bonneville redside shiner, *Richardsonius balteatus hydrophlox*

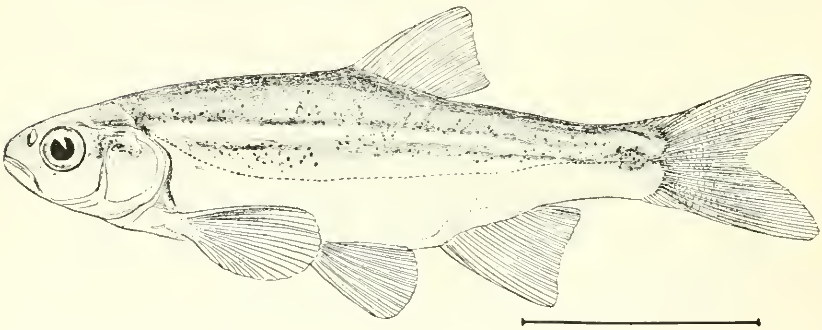

FIGURE 25. Bonneville redside shiner (nuptial male)

24b. Anal fin small, typically with 7 to 9 rays (occasionally 10 in *Notropis lutrensis*), the fin margin nearly straight or rounded. Origin of dorsal fin over or behind that of pelvics. Lateral line not notably decurved.

27a. Scales very large, fewer than 40 along lateral line .... Plains red shiner, *Notropis lutrensis lutrensis*

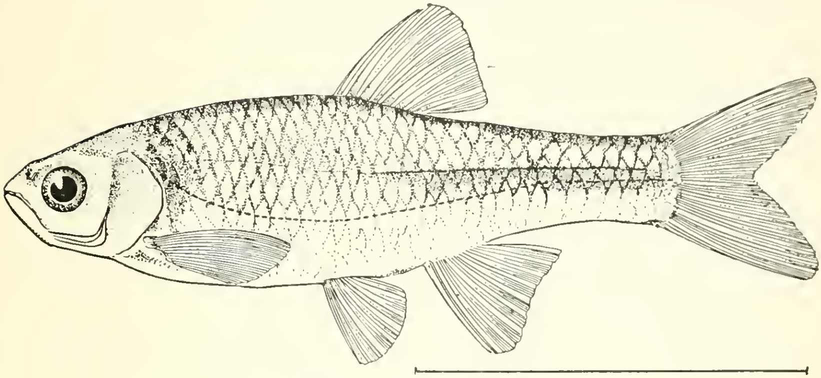

FIGURE 26. Plains red shiner

27b. Scales moderate to very small, about 45 to 95 along lateral line.

28a. Anal fin with 7 rays only (very rarely 8 in *Rhinichthys*). Size small.

29a. Origin of dorsal fin directly over that of pelvics. Scale radii on apical and lateral fields only. Head short, rounded, blunt .... Southwestern fathead minnow, *Pimephales promelas confertus*

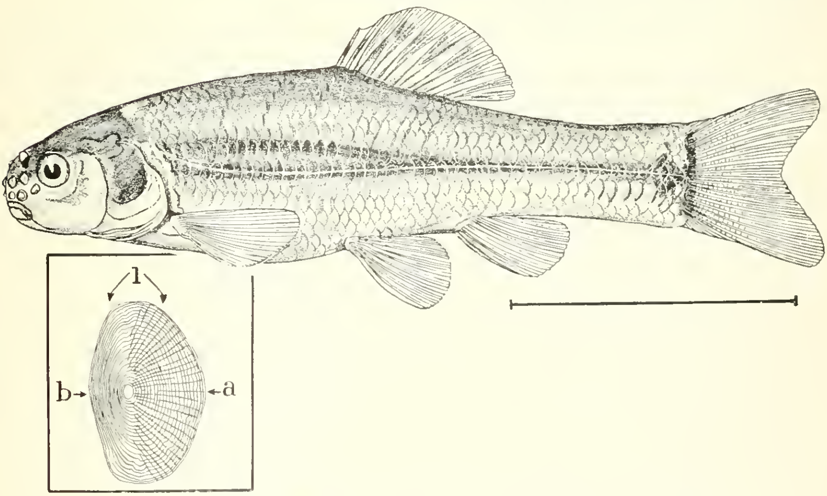

FIGURE 27. Southwestern fathead minnow (nuptial male). Inset shows scale.

29b. Dorsal fin located well behind pelvics. Scale radii on all fields, like the spokes of a wheel (Figure 29). Head not notably short, rounded and blunt.

30a. Sides of body silvery. Scales very small, usually 75 to 90 in lateral line. Anal fin of adult elongate, particularly in the breeding male. (Teeth 4-4, a small barbel invariably present.) ____________ Longfin dace, *Agosia chrysogaster*

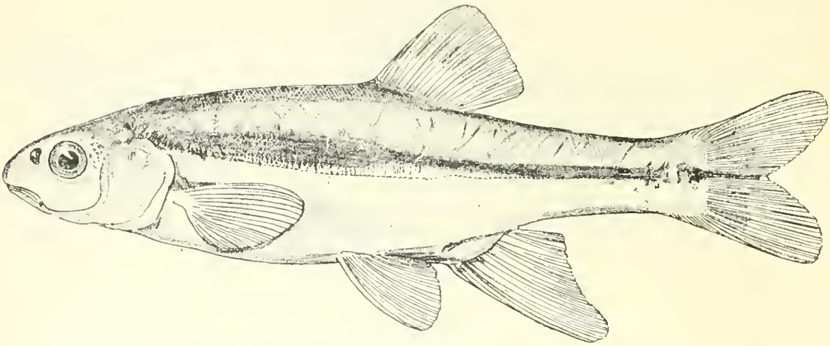

FIGURE 28. Longfin dace (male).

30b. Sides of body speckled ("salt and pepper" effect) or with a longitudinal band (or bands). Scales not so small, about 55 to 70 in lateral line. Anal fin not notably elongate. (Teeth 1, 4-4, 1, or 2, 4-4, 2, barbel present or absent.) ____________ Speckled dace, *Rhinichthys nubilus*

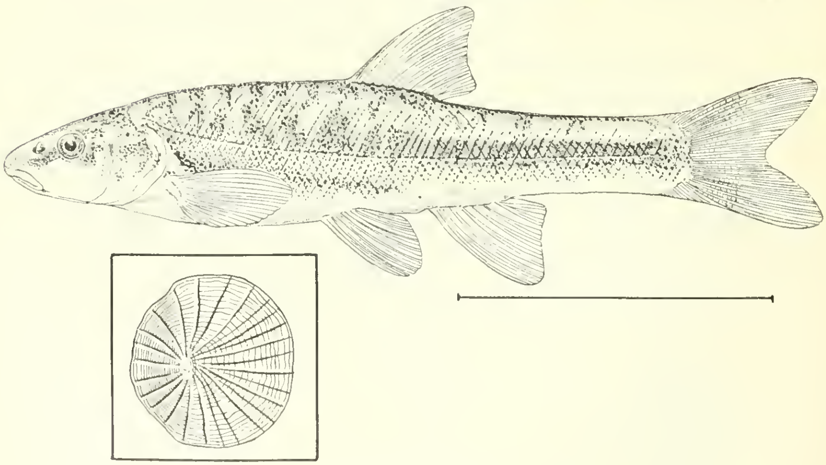

FIGURE 29. Speckled dace. Inset shows scale.

28b. Anal fin larger, typically with 8 rays. Size larger.

31a. Origin of dorsal fin over that of pelvics. Dorsal rays usually nine (occasionally eight). Radii on apical field of scale only. Body plain dark brownish or black, with yellowish cast. (Teeth 2, 5-4, 2, gill rakers 10 to 15, lateral-line scales 51 to 63.) __ Utah chub, *Gila atraria*

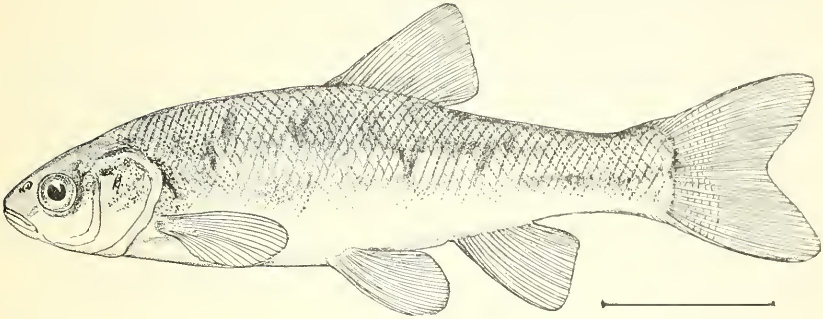

FIGURE 30. Utah chub

31b. Origin of dorsal fin behind that of pelvics. Dorsal rays typically eight. Scales with radii on apical and lateral fields. Coloration not uniform. (Teeth 2, 5-4, 2 in *G. nigrescens*, 2, 4-4, 2 in *Snyderichthys*, gill rakers 7 to 9, lateral-line scales 55 to 80.)

32a. Scales in lateral line fewer than 70. Sides of body often marked by two horizontal dark bands ________________ Río Grande chub, *Gila nigrescens*

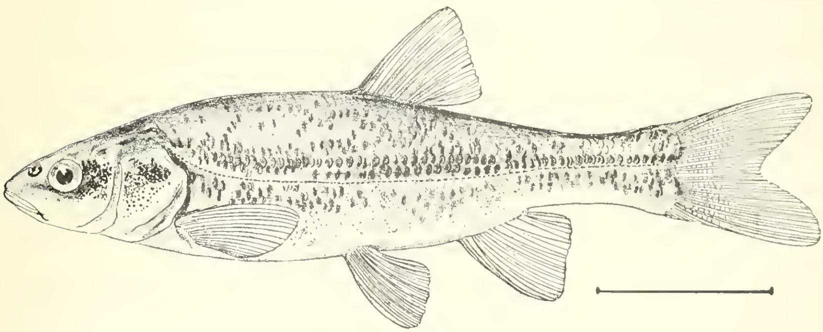

FIGURE 31. Rio Grande chub

32b. Scales in lateral line 70 to 80. Body bluish above, silvery below, with a dusky lateral shade and a leathery texture to the skin
------ Leatherside chub, *Snyderichthys aliciae*

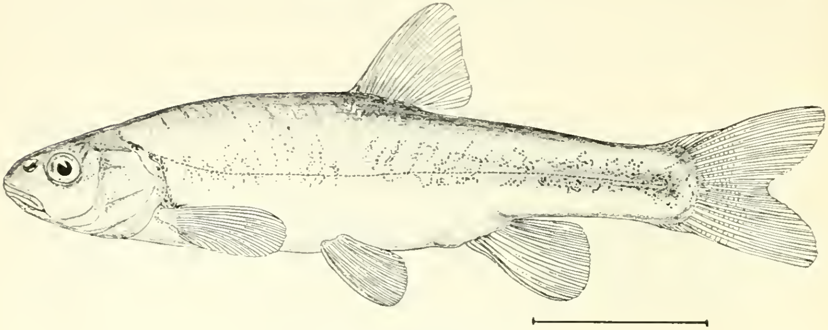

FIGURE 32. Leatherside chub

CHARACIN FAMILY (*CHARACIDAE*)

The American characins are almost wholly confined to South and Middle America. A single species reaches the United States in western Texas and New Mexico.

Mexican Banded Tetra, *Astyanax fasciatus mexicanus* (Filippi). Figure 1.

This characin was first recorded as a bait fish along the Colorado River by Evans and Douglas (1950) on the basis of specimens offered for sale at Bob Williams' Bait Shop in Yuma, Arizona. These individuals were examined by C. L. Hubbs and the writer on March 23, 1950.

The Mexican banded tetra evidently was accidentally included in a shipment (or shipments) consisting mostly of fathead minnows, *Pimephales promelas*, that came from Truth or Consequences (formerly Hot Springs) on the Río Grande, New Mexico. These fish were being sold at Fisher's Landing, Laguna Dam, about 14 miles above Yuma, and in the Yuma area—only on the Arizona side of the Colorado River.

The aggressive and frequently vicious nature of this sharp-toothed characin is known to those who have had first-hand experience with it (Breder, 1943). The voracious nature of this species was conclusively proven to me from observations I made on a closely related subspecies in the lowlands of Guatemala in 1946 and 1947.

Under no circumstances should this potentially dangerous carnivore be used for bait, for its establishment in the Colorado River might well have a disastrous effect on the fishery.

SUCKER FAMILY (*CATOSTOMIDAE*)

This common group of fishes is largely restricted to North America. Two species live in eastern Asia and one penetrates southward to Guatemala.

Western White Sucker, *Catostomus commersoni suckleyi* **Girard.**[6] **Figure 11.**

This sucker, which is native to the streams of the eastern slope of the Rocky Mountains, was probably introduced as bait into the upper Colorado River near Hot Sulphur Springs, Grand County, Colorado, about 1938 (Hubbs, Hubbs, and Johnson, 1943, p. 12-13 and 39-40). It was first collected in the Colorado system on April 21, 1941, when John T. Greenbank took an adult in Dry Creek, three miles west of Olathe, Montrose County, Colorado. Since then it has rapidly increased (Hubbs and Hubbs, 1947, p. 153-154).

A single yearling sucker, which probably is this species, was brought in by Philip Douglas from Kinder's Camp, California, where it was collected on June 21, 1950. There is the slight possibility that it may be an aberrant specimen of the Utah sucker, *Catostomus ardens* Jordan and Gilbert.

This species may have come from Green River, Utah, a locality frequently mentioned to me by bait distributors as one from which bait collectors have secured their specimens. If so, the western white sucker is spreading down the Colorado system.

Catostomus commersoni inhabits both streams and lakes and is one of the species preferred for propagation as a bait fish in the Great Lakes region. However, its use for this purpose along the lower Colorado River is not recommended at this time for the reason that other species of suckers which are native to these waters may well prove to be as suitable or even more so.

Utah Sucker, *Catostomus ardens* **Jordan and Gilbert. Figure 12.**

This sucker is native to the basin of ancient Lake Bonneville, which covered most of Utah and adjacent parts of Idaho, Wyoming and Nevada, and to the upper Snake River (above Shoshone Falls), in Idaho and Wyoming. It is an adaptable species, living in lakes, rivers or creeks at warm to very cold temperatures, in slow to rapid current, in silty to clear water where the bottom varies from soft mud to clay, gravel and stones, and where there is usually some algae or submerged plants or both. In Bear Lake, it lives in water at least as deep as 76 to 80 feet (data through courtesy of Dr. R. M. Bailey).

This species has been taken twice from bait tanks along the lower Colorado River. Al Jonez, of the Nevada Fish and Game Commission, obtained one yearling from a bait box on Lake Mead in February, 1951, and Richard D. Beland, of the California Department of Fish and Game, picked up a yearling from the Havasu Springs Resort, Arizona, on April 10, 1951. The bait at the latter locality was reported by George Savard to have come from A. G. Sessions at Marysvale, Utah. This is on the Sevier River, a stream in which the Utah sucker is common.

In Wyoming, the Utah sucker attains a length of $25\frac{1}{2}$ inches and a weight of more than 12 pounds and is known to eat trout eggs when available. (Simon, 1946, p. 56-57; species recorded as *C. fecundus*). This species is highly adaptable and has occurred in Utah Lake, Utah, in excessive numbers (Jordan, 1891, p. 31). Its establishment in the Colorado River, however, would probably prove to be harmless to the fishery.

[6] The nomenclature throughout this paper is brought into line with the recent revisions in the International Rules of Zoological Nomenclature (Bulletin of Zoological Nomenclature, 1950).

Flannelmouth Sucker, ***Catostomus latipinnis*** **Baird and Girard. Figure 10.**

The flannelmouth sucker, so named because of the long, fleshy lobes of the lower lips in large adults, is one of the few species of native fishes found throughout the Colorado River system. The streamlined body admirably adapts this fish to a swift-water habitat, to which adults are confined. To my knowledge, however, this species has never been collected from the Colorado River below the Virgin River, the mouth of which is now flooded by Lake Mead. It is known from the Gila River drainage of southern Arizona, where, however, it is very rare.

Two subspecies have been recognized (as by Hubbs, Hubbs, and Johnson, 1943, p. 60), but the basis for this separation is so insecure that it seems unwise, for the present, to continue the use of trinomials.

This species was first noted as a bait fish by C. L. Hubbs on August 31, 1938, at Alexander's Bait Shop, Las Vegas; Mr. Alexander's source was the Virgin River west of Bunkerville, Nevada. On December 31, 1948, O. L. Wallis obtained a specimen (reportedly from Santa Clara River, Utah) at the Lake Mead Boat Dock. The flannelmouth sucker was secured by our party at the Lake Mead Boat Dock and from two bait dealers at Pittman, Nevada, on June 16, 1950. It was also collected by Richard D. Beland in December, 1950, from Shorty's Bait Shop at Topock, and on June 21, 1950, two flannelmouth suckers were brought in by Philip Douglas from Kinder's Camp.

Most of the flannelmouth suckers that I have examined evidently came from the upper Colorado River, perhaps from the Green River basin or from the vicinity of Grand Junction, Colorado (the occurrence of this species and the western white sucker in the same bait tank suggests this latter source). However, the specimens from Las Vegas and Lake Mead came from the Virgin River and probably the Santa Clara River, respectively. Milt Holt, bait collector at Gunlock, Utah, has written (letters of March 18 and April 10, 1951) that he collects most of his fishes from Santa Clara River and Beaver Dam Wash, southwestern Utah, and that he has delivered bait to eight retailers in the Lake Mead area (including the two at Pittman). We collected flannelmouth suckers from Santa Clara River, 2½ miles below Gunlock on June 17, 1950.

This species typically has 12 or 13 (10 to 14) dorsal rays in the upper Colorado River (above Lees Ferry), 13 or 14 (12 to 15) in the Virgin River basin, and 13 to 15 (only 17 specimens counted) in the Gila River basin. Counts of nine specimens from the Pittman dealers gave a range of 10 to 13 (usually 12) dorsal rays which indicates, substantiating the testimony of the dealers, that these suckers came from the upper Colorado. The two Lake Mead specimens each had 13 dorsal rays. The two specimens from Kinder's Camp (counted by C. L. Hubbs) had 11 and 12 rays and each of the two from Shorty's Bait Shop (also counted by Hubbs) had 10 dorsal rays—clearly indicating importation from some point above Grand Canyon.

It is questionable if the flannelmouth sucker will become established in the lower river or its reservoirs as the habitat is unsuitable in the reservoirs and competition with trout would probably exclude the species in the swift, cold waters below the dams. The apparent absence of this species in the original river also argues against its possible establishment there now. This species is therefore regarded as a harmless bait fish.

Bluehead Mountain-Sucker, *Pantosteus delphinus* (Cope). Figures 15 and 16.

This sucker is not quite so widespread in the Colorado River as the flannelmouth, for it is unknown from the Gila River basin. It is common in the streams of the Virgin River drainage, where the adults seek the swift waters of riffles or the pool heads where the current is turbulent; the young may occur in quieter water. Like other mountain-suckers, this fish is a bottom feeder, eating much algae which it scrapes from rocks with the chisel-like ridge inside each lip. Because of their rapid- to very swift-water habitat, it was a surprise to find them surviving so well in bait tanks.

Two subspecies may be recognized (see Figures 15 and 16): a very fine-scaled form with a conspicuously slender caudal peduncle, called *Pantosteus delphinus delphinus* (Cope), and a coarser-scaled form with a deeper caudal peduncle, called *Pantosteus delphinus utahensis* (Tanner).

This species has been detected in bait dealers' boxes as follows: Alexander's Bait Shop, Las Vegas, August 31, 1938, C. L. Hubbs (*P. d. utahensis*, Virgin River); Lake Mead Boat Dock, December 31, 1948, O. L. Wallis (*P. d. utahensis*, Santa Clara River); Pittman, Nevada (two dealers), June 16, 1950, R. R. Miller and H. E. Winn (*P. d. delphinus*); Shorty's Bait Shop, December, 1950, R. D. Beland (two identified by C. L. Hubbs as *P. d. delphinus* and two others as *P. d. utahensis*); Murphy's Windmill Camp, February 3, 1951, R. D. Beland (6 *P. d. utahensis* and one not certain as to subspecies); bait box on Lake Mead, February, 1951, Al Jonez (two small adults, *P. d. utahensis*).

The streamlined subspecies (*delphinus*) very probably came from Green River, a known bait source for fishes handled by the dealers at Pittman. The chubbier form (*utahensis*) undoubtedly (except for the one sample known to have come from Virgin River) came from Santa Clara River near Gunlock, Utah, a stream in which it abounds and from which bait samples are taken.

Neither of these native subspecies is likely to become established in the lower river or its reservoirs; even if they should adapt themselves successfully, it is not expected that they would do so in numbers great enough to affect the fishery adversely. The local subspecies, *P. d. utahensis*, is regarded by Milt Holt as his best bait. Whether this fish can be propagated is not known, but some species of *Pantosteus* may live two or more years in dirt tanks (personal observation).

Bonneville Mountain-Sucker, *Pantosteus platyrhynchus* (Cope). Figure 14.

This species is native to the Bonneville basin, Utah, and the Snake River above Shoshone Falls. It inhabits cool, moderately slow to very swift waters, living in pools, on riffles and in rapids. It is one of the common fishes of the Bonneville basin.

The first specimen of the Bonneville mountain-sucker from the Colorado River to come to my attention is a small adult deposited in the Lake Mead Recreational Area Museum and bearing the following data: "Lake Mead, September 8, 1938, collected by Johnny Westen." This record received advance notice by Wallis (1951, p. 89). The data are meager but it seems evident that this specimen represents a bait introduction, possibly from the Sevier River, Utah. That bait fishes were being handled as early as 1938 is evident from the testimony of Milt Holt and also from

the field records of C. L. Hubbs. On July 3, 1938, he interviewed Clarence Alexander of Las Vegas, who was supplying live bait for the fishing at Lake Mead. This species was not, however, one of those noted in Mr. Alexander's tanks, for he reported that his fishes were seined in the Virgin River west of Bunkerville, Nevada, and thus not within the natural range of this sucker.

On February 3, 1951, R. D. Beland obtained a small specimen of this species from Murphy's Windmill Camp, California, and on April 10, 1951, he picked up three specimens at Havasu Springs Resort, Arizona. The latter were reported by George Savard to have come from A. G. Sessions at Marysvale, Utah, on the Sevier River.

It is not expected that this species will become established in the Colorado River and hence its use as bait seems harmless. It is possible that this sucker might be more suitable for propagation than the bluehead mountain-sucker. A. G. Sessions of Marysvale, Utah, reports that he is attempting to propagate this fish. Simon (1946, p. 60) wrote that, where plentiful, this species is an important forage and bait fish in Wyoming.

Río Grande Mountain-Sucker, *Pantosteus plebeius* (Baird and Girard).[7] Figure 17.

The precise range of this species is imperfectly known but it is generally attributed to the Río Grande, in Colorado and New Mexico, and to streams of northern Mexico. Its preferred habitat is similar to that of other mountain-suckers—rather shallow, swift, cool water.

The only record of this species as a bait fish along the Colorado River is of a single yearling identified by Hubbs and secured by Willis A. Evans on July 5, 1950, from the Intake Store, California.

This specimen evidently came from the basin of the Río Grande, probably in New Mexico (as the genus is not known to occur naturally in Texas). A logical source is Truth or Consequences (formerly Hot Springs), where bait is propagated (see account of fathead minnow).

The Río Grande mountain-sucker is no more likely to become established in the Colorado than the previous species of *Pantosteus*, and it is therefore judged to be harmless.

Dusky Mountain-Sucker, *Pantosteus* species. Figure 13.

This species is only known from the northern part of Spring Valley, an interior basin lying to the east and northeast of Ely, Nevada. It was first collected there by Hubbs and Miller in 1938, at which time it was so rare that only three specimens were secured.

On June 16, 1950, Miller and Winn obtained two half-grown specimens from the Shell Oil Station at Pittman, Nevada, and Richard Beland obtained a small adult from Murphy's Windmill Camp on February 3, 1951. The latter evidently was supplied by the Pittman dealer where we saw numbers of live individuals of this species. The Pittman dealer told me that this sucker came from near Caliente, Nevada (in the drainage of Meadow Valley Wash), but careful comparison with specimens of the *Pantosteus* inhabiting that region fails to confirm this testimony. Spring Valley is about 100 miles north of Caliente, and evidently was the real source.

[7] Researches to date on the genus *Pantosteus* strongly suggest that *P. plebeius* is confined to tributaries of Lake Guzman in southern New Mexico and northern Chihuahua, Mexico. If so, the Río Grande species should have a different name, but what name is not yet clear.

The further use of this species for bait is to be discouraged because of its restricted range and the desirability of conserving an interesting species for posterity.

MINNOW FAMILY (*CYPRINIDAE*)

The members of this diverse group of fishes, commonly called chubs, shiners, dace, etc., are usually small. Like the suckers, they have no jaw teeth but do have pharyngeal teeth, deep in the throat. One of the largest minnows in the world, the so-called "Colorado salmon" (*Ptychocheilus lucius*), is still rarely taken in the lower Colorado; in former years when it was abundant, it is said to have reached a length of six feet and a weight of 100 pounds.

Minnows are of considerable economic importance, for their wide distribution and abundance make them important in the food cycles of all predacious fishes. Their value for bait is well proven.

More than 200 species of minnows are recognized in the United States and since many are very similar in appearance their identification is often difficult, even for the specialist. Fifteen species have thus far (May 1, 1951) appeared in the bait tanks and boxes along the lower Colorado River.

Carp, *Cyprinus carpio* Linnaeus. Figure 18.

This well-known species, originally from Asia, has been established in the river for more than 60 years (Gilbert and Scofield, 1898, p. 487). Its preferred habitat is warm rivers and lakes. Although the early introduction of carp into the United States was hailed, this fish has repeatedly been condemned by biologists and most laymen. Since it is an extremely hardy and prolific fish, attempts to rid our waters of it have generally proved to be fruitless.

Young carp appear sporadically in bait tanks along the river and have been used either as live bait or cut bait for some time (Dill, 1944, p. 153). The two varieties—mirror (with a few enlarged scales) and leather (largely scaleless)—are not infrequently seen. Carp were being sold for \$1.25 per dozen at Shorty's Bait Shop, on April 7, 1950, and this species was the chief bait handled. Bob Bolam, operator of the Needles Boat Landing, told me on June 15, 1950, that he sells young carp for bait and that they come from Pahranagat Lakes, Lincoln County, Nevada. We identified a few specimens in his bait tank. Small carp were also being sold by the two dealers at Pittman, on June 16, 1950; these were reported to have been brought in by youngsters from Nevada, perhaps from the same Pahranagat Lakes which are readily accessible and are known to contain carp. The species (leather variety) was also noted by Philip Douglas (identified by C. L. Hubbs) at Kinder's Camp on June 21, 1950, and by R. D. Beland at Havasu Springs Resort on April 10, 1951.

Since the carp is already excessively abundant in sections of the river its continued introduction will probably not affect the fishery.

Goldfish, *Carassius auratus* (Linnaeus). Figure 19.

This familiar aquarium and pond fish has been widely transplanted from its original home in eastern Asia. Warm lakes and quiet streams, with abundant vegetation, are its preferred habitats.

The only published record of the use here of this species for bait, of which I am aware, is that by Dill (1944, p. 177), who said that goldfish were kept for bait in live-boxes at Lake Havasu. None was seen along the river or in it during our short survey, but O. L. Wallis wrote (April 16, 1951) that this species was being used for bait at Temple Bar Wash, Arizona, in March, 1949. Mr. Wallis was told that fishermen from Kingman were bringing in the goldfish.

It is doubtful if this species will become adapted to the Colorado River, although it might gain a foothold in the warmer parts of the reservoirs. Its use as a bait fish is not recommended.

Speckled Dace, ***Rhinichthys nubilus*** **(Girard).[8] Figure 29.**

This exceedingly variable species is widely distributed over the western United States. Within the limits of its range, it has evolved into a confusing array of local kinds, the status of which is imperfectly known. Hence, for the purposes of this paper, no subspecific designations will be used, although it has often been possible to recognize the general or even precise source of the several kinds that have appeared in bait tanks.

The conditions to which the speckled dace is adapted vary from swift, cold riffles of mountain streams and the strong current of lower, warmer rivers, to less rapid waters and to the quiet conditions of isolated warm springs and their outflow ditches.

This species has been taken from bait tanks at the following places: Alexander's Bait Shop, Las Vegas, C. L. Hubbs, August 31, 1938 (from Virgin River west of Bunkerville, Nevada); Lake Mead Boat Dock, O. L. Wallis, December 31, 1948 (two types, source uncertain, one probably Santa Clara River); Pittman (two dealers), Miller and Winn, June 16, 1950, two distinct stocks, one from "Green River" and the other from Meadow Valley Wash, evidently in the vicinity of Caliente, Nevada; Kinder's Camp, P. A. Douglas, June 21, 1950, seven adults, probably from the Virgin River system; Shorty's Bait Shop, R. D. Beland, December, 1950, two stocks (as identified by C. L. Hubbs), one from the Bonneville basin (evidently Sevier River, Utah) and the other from the Virgin River system; Murphy's Windmill Camp, Richard Beland, February 3, 1951, two stocks—one from Meadow Valley Wash in southeastern Nevada, and the other from the Virgin River system (probably from Santa Clara River); bait box on Lake Mead, Al Jonez, February, 1951, said to be from the "St. George, Utah, area" (probably from Santa Clara River).

The kind attributed to Green River (handled by the Pittman dealers) is known to occur in San Rafael and Fremont rivers, tributaries to the Colorado River below its junction with the Green River. Specimens are in the University of Michigan collections from near Emery and near Huntington, Emery County, Utah. It is significant that these localities are on the shortest route from Green River to Lake Mead and the lower Colorado and I conclude that during their drive from Green River, the bait collector (or collectors) evidently stopped to pick up these dace en route.

Since this species was unknown in the original lower Colorado River, evidently because it is not fitted to live in such an environment, and since the new river and its reservoirs are probably an even poorer habitat for

[8] *R. nubilus* has line priority over *R. osculus*, the name usually applied to this species, and is now to be used according to the revised International Rules of Zoological Nomenclature (Bulletin of Zoological Nomenclature, 1950, p. 328).

it, I do not believe that any possible harm can come to the fishery from the use of the speckled dace for bait. Its suitability for bait may be questioned since it seldom attains a large enough size. However, the species is an important bait fish in certain parts of Wyoming (Simon, 1946, p. 75-76, 78).

Bonneville Redside Shiner, *Richardsonius balteatus hydrophlox* (Cope). Figure 25.

This brightly colored fish is a characteristic inhabitant of the creeks and rivers of the Bonneville basin, the upper Snake River (above the falls), and certain upper tributaries of the Columbia River and lower Snake River. It also has been taken in lakes, as in Utah Lake, Utah, Bear Lake, Idaho and Utah, Two Ocean Lake, Wyoming, and in Lake Malheur, Oregon.

The Bonneville redside shiner has been sampled from bait tanks along the river as follows: Shorty's Bait Shop, Miller and party, April 7, 1950; Pittman (dealer in Shell Oil Station), Miller and Winn, June 16, 1950; Kinder's Camp, P. A. Douglas, June 21, 1950 (identified by Hubbs); and Shorty's Bait Shop, R. D. Beland, December, 1950. This shiner has 9 to 13, typically 10 to 12, anal rays, which readily distinguishes it from the Columbia redside shiner, *Richardsonius balteatus balteatus* (Richardson), which has 13 to 22, usually 14 to 18, anal rays (Miller and Miller, 1948, p. 183).

This species is usually abundant in its natural range and has already become established in the Colorado River system in Wyoming, through introduction as a bait fish (Simon, 1946, p. 81). Its spread in the Green River drainage is indicated by the capture of a specimen by W. F. Sigler and party from Sheep Creek, Daggett County, Utah, on August 6, 1950. It is carnivorous and has been observed to prey upon newly released grayling fry, but most of its food consists of small aquatic insect larvae and crustaceans (Simon, 1946, p. 82). It attains a length of $5\frac{1}{4}$ inches in Wyoming and is used as a bait fish there. Since its establishment in the lower Colorado might be detrimental, I recommend that this species not be used for bait.

Utah Chub, *Gila atraria* (Girard). Figure 30.

This fish is widely distributed in springs, streams and lakes of the Bonneville system and the upper Snake River in Utah, Idaho, Wyoming and extreme eastern Nevada. It is a prolific and hardy minnow, abounding in most of the waters where it occurs and often crowding out its fish associates.

Utah chubs have been noted in bait tanks at the following places: Kinder's Camp and Shorty's Bait Shop, Miller and party, April 7, 1950; at both the dealers in Pittman, Nevada, Miller and Winn, June 16, 1950; Kinder's Camp, P. A. Douglas, June 21, 1950 (identified by Hubbs); Shorty's Bait Shop, R. D. Beland, December, 1950 (determined by Hubbs); Murphy's Windmill Camp, R. D. Beland, February 3, 1951.

When introduced into other waters, particularly lakes or reservoirs, this species may multiply quickly so as overpopulate such waters. For example, in Strawberry Reservoir east of Provo, Utah, the Utah chub became so abundant that a special trash fishery was set up to handle the menace (see The Progressive Fish-Culturist, Vol. 11, No. 1, 1949, p. 85-86). In Fish Lake, Utah, the introduction of this species for bait led

to a marked decrease in the important trout fishery (Hazzard, 1936, p. 127-128; Davis, 1940, p. 6). The species reaches a length of 16 inches and a weight of more than two pounds (Simon, 1946, p. 78) and can prey on the young of game fishes. For these reasons, the use of the Utah chub for bait should be strictly prohibited. Unfortunately, this undesirable fish may already have gained a foothold in the river. Mr. Richard D. Beland, in a letter to the author (April 29, 1951), wrote that Bob Bolam (Needles Boat Landing) reported that in early April, 1951, he observed an angler catch a nine-inch "Utah minnow" near his pier.

Río Grande Chub, *Gila nigrescens* (Girard).[9] Figure 31.

The distribution of this chub is generally attributed to include the Río Grande drainage in Colorado, New Mexico and Texas, from which it ranges southward an unknown distance into Mexico. This species typically lives in small, cool streams, with moderate to swift current, and is a midwater swimmer, frequenting the pools.

There is only one record of this species from bait tanks along the Colorado River. It was taken by Willis Evans on July 5, 1950, from the Intake Store (identification by C. L. Hubbs).

Little is known about this chub and, for that reason, it would probably be wise to discourage its use for bait until more information on its life history is available.

Leatherside Chub, *Snyderichthys aliciae* (Jouy). Figure 32.

This species, known for many years as *Gila copei* (Jordan and Gilbert),[10] is another inhabitant of the Bonneville basin and the upper Snake River. Its distribution has been discussed by Hubbs and Miller (1948, p. 31, 77). This minnow typically inhabits small, clear streams, where the adults live either in pools or on swift riffles.

The leatherside chub has been taken as follows: Kinder's Camp and Shorty's Bait Shop, Miller and party, April 7, 1950; Pittman (Shell Oil Station), Miller and Winn, June 16, 1950; the Lake Mead Boat Dock, R. K. Grater, about August 1, 1950; Shorty's Bait Shop, R. D. Beland, December, 1950; and Havasu Springs Resort, R. D. Beland, April 10, 1951. Most of these specimens probably came from Marysvale, Utah.

This is one of the three species of minnows which, through introduction as bait, has become established in Strawberry Reservoir, Utah. However, its effect upon the lower Colorado River fishery would probably not be harmful.

Golden Shiner, *Notemiganus crysaleucas* (Mitchill). Figure 23.

The golden shiner is an inhabitant of weedy lakes and the quieter sections of rivers where it is commonly found amongst dense vegetation. The species is one of those preferred for propagation as a bait or forage fish in the east, and ranges widely over eastern North America from southeastern Canada southwestward as far as the mouth of the Río Grande (one record in 1878). Two subspecies have been identified among

[9] As with the Río Grande mountain-sucker, this species may be confined to the basin of Lake Guzman.

[10] The specific trivial name *copei* cannot be used because at one time *Gila copei* and *Leuciscus copii* (a *Notropis*) were both placed in *Leuciscus*, thereby creating a secondary homonym. This fact was recognized by Gilbert and Evermann (1894, p. 195) who used the combination *Leuciscus aliciae*. Miller (1945, p. 28) proposed the generic name *Snyderichthys*.

the bait samples secured along the Colorado River: *N. c. seco* (Girard), the Southwestern golden shiner, and *N. c. auratus* (Rafinesque), the Western golden shiner. These subspecies are very similar and their distinctive characters have not been fully worked out. They are usually distinguished on the basis of the number of anal rays: 10 to 14, usually 11 to 13, in *auratus*, and 11 to 16, usually 12 to 14, in *seco*.

This minnow was obtained by Willis Evans from the Intake Store, on July 5, 1950, along with four other species of fishes that occur in the southwest. This stock probably came from the vicinity of Lake Buchanan, a reservoir on the Colorado River in Llano and Burnett counties, Texas, and hence is referred to *N. c. seco*. Kirby H. Walker learned that bait minnows from this source were supplied to the Arizona Fish Farms, Inc., which operates opposite Blythe in Arizona.

Although the golden shiner was established in certain lakes of the Coconino National Forest, Arizona, by or before 1934 (Madsen, 1935, p. 9), and had subsequently contributed to the deterioration of the trout fishery resource in that region,[11] it is not likely to become established in the Colorado River or its reservoirs because of the absence of large weed beds. The golden shiner is well adapted to pond culture, attains a good size (up to 10 inches) and grows rapidly. It is an important bass forage fish in the midwest. This species is believed to be well suited as a bait fish along the lower Colorado River as long as the present sparseness of submerged aquatic vegetation persists. Should this over-all situation change, and extensive weed beds become common, this species might contribute to a reduction of the fishery as it did in Upper Lake Mary, Arizona (see footnote 11). At the present time attempts are being made by the California Department of Fish and Game to propagate Western golden shiners in an isolated pond near Blythe. It is also being raised in a 10-acre pond (along with *Notropis lutrensis*) by the Arizona Fish Farms, Inc., who have recently obtained stocks of *N. c. auratus* from San Dieguito Reservoir near San Diego (letter of August 15, 1951, from W. A. Evans to W. A. Dill).

Sacramento Hitch, ***Lavinia exilicauda exilicauda*** **Baird and Girard. Figure 24.**

This exclusively Californian fish inhabits the Sacramento-San Joaquin drainage system, including streams tributary to San Francisco Bay. A closely related subspecies lives in the Pajaro and Salinas Rivers and their tributaries in west-central California. The hitch prefers the lower, sandy to muddy, slow-moving stretches of rivers or the quiet pools of creeks, generally in fairly warm water. According to Murphy (1948, p. 101) it appears to require gravel-bottomed streams for successful spawning. It feeds, in large part at least, on fine microscopic organisms (plankton), as shown by the rather numerous gill rakers, the long intestine and the grinding type of pharyngeal teeth. The hitch closely approaches the golden shiner in general appearance but lacks the distinctive fleshy keel on the abdomen which distinguishes the golden shiner.

The hitch has appeared in bait tanks as follows: Site Six, Lake Havasu, P. A. Douglas, March 2, 1950; Kinder's Camp, Miller and party, April 7, 1950; and at the same place, P. A. Douglas, June 21, 1950.

[11] Unpublished report, 1949, by H. Milton Borges, in the files of the Arizona Game and Fish Commission; sent to me through the courtesy of A. W. Yoder.

This minnow unquestionably was imported from the Central Valley of California. Milt Holt wrote me (March 18, 1951) that he collected bait "north of Modesto" late in 1949 and early in 1950. Vic Spratt, operator of the Site Six camp, told P. A. Douglas that his hitch were being trucked and flown to Site Six from Fresno by C. L. Ballard, Jr., and Mr. Kinkillea. In order to limit the species of bait fishes, and because the biological effect of this species is problematical, its further use for bait is not recommended.

Plains Red Shiner, *Notropis lutrensis lutrensis* (Baird and Girard). Figure 26.

This fish ranges widely over the central United States, from Illinois and South Dakota southward and westward to the basin of the Río Grande in Texas and New Mexico; its distribution in northern Mexico is imperfectly known. It is an inhabitant of both creeks and rivers, tolerating the muddy waters of the Great Plains.

This shiner has been taken only at the Intake Store north of Blythe. Five specimens were obtained there by Willis Evans on July 5, 1950, and three more were secured on September 6, 1950, by Donald E. Wohlschlag. The stock came from the vicinity of Lake Buchanan, Texas, according to information kindly obtained by Kirby H. Walker. The shiners were transported to the Arizona Fish Farms, Inc.

It is doubtful if this species will become established in the Colorado River as the present habitat there seems wholly unsuited to it. The use of this shiner for bait is therefore not considered to be harmful; however, its suitability as a bait fish may be questioned since it is regarded to be too small for a desirable bass bait. Kirby H. Walker informs me (letter of April 27, 1951) that the Arizona Fish Farms, Inc., has a 10-acre pond devoted to the propagation of this species (as well as golden shiners).

Southwestern Fathead Minnow, *Pimephales promelas confertus* (Girard). Figure 27.

The species *Pimephales promelas* ranges widely over eastern North America, from southern Canada and New York westward and southward between the Appalachians and the Rockies to northern Mexico. The southwestern type is a typical inhabitant of silty lakes and streams.

The only record at hand of this fish from bait tanks is of specimens offered for sale at Williams' Bait Shop (Evans and Douglas, 1950, p. 435). These fish were imported from Truth or Consequences (Hot Springs), New Mexico, where they are being reared in bait tanks adjacent to the Río Grande below Elephant Butte Dam.

The fathead minnow eats chiefly microscopic plant foods but will also take insects and smaller animal life. It is a prolific and hardy fish and is ideal for propagation in ponds. In the midwest it is a popular bait for panfish and its use as a bait fish on the Colorado River is to be encouraged.

Longfin Dace, *Agosia chrysogaster* Girard. Figure 28.

This little silvery minnow is the commonest native fish in the Gila River drainage of southern Arizona and southwestern New Mexico, at low to medium elevations (generally below 4,500 feet). It persists in desiccating streams to the last water hole and is usually abundant wherever found. To the north of the Gila drainage it occurs only in the Bill Williams River of western Arizona (Miller, 1946, p. 206).

The longfin dace was first observed along the Colorado River on April 2, 1948, when Leo Rossier obtained specimens from Shorty's Bait Shop

(Evans and Douglas, 1950, p. 435). On June 13, 1949, April 7, 1950, and December, 1950, this fish was again noted at the same place.

Reports indicate that this species is being brought in from the Bill Williams River drainage and from Hassayampa River, just below Wickenburg, Arizona. It is abundant in both areas. The report of this fish from a tributary of Virgin River (Evans and Douglas, 1950, p. 435) probably stems from the fact that distributors receive some of their bait from that drainage and are not able to distinguish between the different kinds of fishes brought to them.

The longfin dace is primarily herbivorous in its feeding habits and is a small-creek fish. Since it has never become established in the Colorado River there is no reason to believe that occasional individuals escaping from fishermen's hooks will build up a population in the river. Consequently it is regarded as a harmless bait fish. It might prove to be an adaptable species for propagation in shallow runways with a coarse sand bottom and slight current. It is known to spawn on such a bottom (personal observations).

Virgin River Spine-dace, *Lepidomeda* species. Figure 21.

This species lives in the Virgin River and its tributaries in Nevada, Arizona and Utah. It is an inhabitant of the rather swift portions of pools, in rapidly flowing creeks.

The Virgin River spine-dace was noted as a bait fish by Carl L. Hubbs when he interviewed Clarence Alexander, bait dealer in Las Vegas, on August 31, 1938. Two specimens were secured by O. L. Wallis from the Lake Mead Boat Dock on December 31, 1948, and three more were picked up from a bait box on Lake Mead by Al Jonez, of the Nevada Fish and Game Commission, in February, 1951.

The specimens for sale by Mr. Alexander, for use on Lake Mead, were seined by him in the Virgin River west of Bunkerville, Nevada. Those picked up by Mr. Jonez were reported to have come from the St. George, Utah, area, likely from Santa Clara River where this species abounds and from which Milt Holt seines his bait and delivers it to the Lake Mead area.

Little information is available on the biology of this fish, but since it is unknown from the main Colorado it is not likely to become established in the present river or its lakes. Consequently its use as a bait fish is probably harmless.

White River Spine-dace, *Lepidomeda* species. Figure 22.

This minnow inhabits the upper White River in White Pine and Nye counties, Nevada, where it lives chiefly in cool springs and their outflows.

On February 3, 1951, Richard Beland obtained four adults from Murphy's Windmill Camp, California. This constitutes the only record to date (May, 1951) of the use of this species as a bait fish along the Colorado River. The specimens must have come from the upper White River.

There is little likelihood that the White River spine-dace will become established in the Colorado River. However, because of its very restricted range, and hence its interest to science, the use of this species for bait should be discouraged.

Woundfin, *Plagopterus argentissimus* Cope. Figure 20.

This streamlined minnow, which shines like burnished sliver when first taken from the water, is now known to inhabit only the Virgin River and its tributaries in Arizona, Nevada, and Utah. It formerly was found in the Gila River basin, from which it has been recorded only three times, the last in 1894.

On June 16, 1950, Miller and Winn obtained one specimen from the boat dock on Lake Mead. Otherwise it has not turned up in the bait tanks along the river.

This is an interesting and gradually vanishing species which should be protected from further reduction.

KILLIFISH FAMILY (*CYPRINODONTIDAE*)

This is a large family of small fishes that are widely distributed in fresh, brackish, mineralized and salt waters of the New World.

Southwestern Plains Killifish, *Fundulus zebrinus* Jordan and Gilbert. Figure 9.

This killifish inhabits the Río Grande (including the Pecos River), in New Mexico and Texas, and probably other rivers in Texas and northern Mexico. It is a fish of rather small, shallow, open streams.

This species was first observed for use as bait on March 23, 1950, at Williams' Bait Shop in Yuma (Evans and Douglas, 1950, p. 435). On July 5, 1950, W. A. Evans secured a specimen (identified by Hubbs) at the Intake Store.

It is doubtful if the Southwestern Plains killifish will establish itself in the lower Colorado River or its reservoirs. Consequently, the use of this species for bait is probably harmless.

Southern California Killifish, *Fundulus parvipinnis parvipinnis* Girard. Figure 8.

This killifish inhabits salt, brackish and fresh waters from Morro Bay, California, to northwestern Baja California. It is commonly found over the mud bottoms of estuaries but also ascends the clear, sandy stretches of streams in the southern part of its range.

The only information that I have concerning the possible use of this fish for bait is contained in a letter, dated April 29, 1951, from Richard D. Beland. On February 14, 1951, he found that Bob Williams (Williams' Bait Shop, Yuma) was holding a number of these fish in his tanks on an experimental basis to determine if they could be handled and used for bait. One specimen was preserved to check the identification and proved to be this fish. Subsequently Beland was informed that attempts to utilize this species for bait had been abandoned.

Mr. Williams reported that his specimens were caught in traps and shipped in from San Diego Bay, California.

The Southern California killifish is not likely to become established in the river, but further attempts to use it as a bait fish are not encouraged because there are other, more suitable species available.

TOPMINNOW FAMILY (*POECILIIDAE*)

The members of this exclusively American family are all small fishes, largely tropical in distribution, and notable because they bring forth their young alive.

Western Mosquitofish, *Gambusia affinis affinis* (Baird and Girard). Figure 7.

This fish, called mosquitofish because of its fame as a destroyer of mosquito larvae, is native to the central United States from southern Illinois to Alabama and the mouth of the Río Grande. It is an inhabitant of quiet, shallow waters where it feeds at or near the surface. It has been widely introduced throughout the world for malaria control.

The inclusion of this fish in the list rests upon the statement by Dill (1944, p. 163) that it has been used as live bait. I did not observe any being so utilized on our recent survey and the species has not been reported from bait tanks in recent months.

The western mosquitofish was planted in California in 1922 (Dill, 1944, p. 162) and eventually reached the Colorado River through its spread for mosquito control.

Since the species is well established in the river, is a good forage fish, and seems to be having no deleterious effect upon the fishery, its use as bait is harmless.

SUNFISH FAMILY (*CENTRARCHIDAE*)

The sunfishes, which include the familiar largemouth black bass and smallmouth black bass, are a truly North American group. All but one species, the Sacramento perch (*Archoplites interruptus*) of California, are native only to the region east of the Rocky Mountains, but many have become widely established in the West through introduction.

Bluegill, *Lepomis macrochirus* Rafinesque. Figure 6.

This well-known fish has been established in the Colorado River for many years (at least since 1938) and is a favorite of the warm-water angler. Three subspecies of bluegill have been recognized in eastern United States; the predominant one in the Colorado River is the northern form, *L. m. macrochirus* Rafinesque. The southwestern bluegill, *Lepomis macrochirus speciosus* (Baird and Girard), collected in Arizona in 1943 (Salt River at Tempe; specimens at University of Michigan), is also now evidently established in the Colorado River through introduction and hence available for bait (*fide* C. L. Hubbs in letter of May 10, 1951, to R. D. Beland, and letter from Beland of August 23, 1951, to W. A. Dill). This subspecies has been distinguished from the northern form by the fewer anal soft rays, 9 to 11 (usually 10) in *speciosus* rather than 10 to 12 (usually 11) in *macrochirus*.

Moffett (1943, p. 185) noted that the bluegill was being used for bait on Lake Mead about 1941, and Dill (1944, p. 171) remarked that this sunfish has value as a bait species and that it is sometimes caught for use as such by bass fishermen. In March, 1949, O. L. Wallis noted that bluegills were being used for bait by bass fishermen at Temple Bar Wash, Lake Mead. It is well established that young bluegills are an excellent forage fish for bass.

Since the bluegill is already a part of the fauna, its continued use as bait cannot be regarded as harmful provided that supplies are not obtained by wholesale seining practices.

Green Sunfish, *Lepomis cyanellus* Rafinesque. Figure 5.

This species is less familiar to fishermen as its introduction in the West has not met with the success accorded the bluegill. It has probably been

established in the river as long as, or perhaps longer than, the bluegill. Dill (1944, p. 172) roughly estimated that this species was outnumbered by the bluegill about 10 to 1.

On June 15, 1950, I identified a few individuals of the green sunfish in Bob Bolam's bait tank at Needles Boat Landing. Dill (1944, p. 173) wrote that the species has value as a bait fish. Its use as such seems to be very limited, however.

Since green sunfish are now a part of the river fauna and since they do not appear to be of major importance in the fishery, their use as bait is not regarded as detrimental.

PERCH FAMILY (*PERCIDAE*)

This group of fishes includes the perches, pike-perches, and darters which, in North America, are native only to the waters east of the Continental Divide.

Yellow Perch, *Perca flavescens* (Mitchill). Figure 4.

This familiar fish is distributed from west-central and eastern Canada south to Nebraska and the northern parts of the central states, and along the Atlantic seaboard from New Brunswick to South Carolina. It has been established elsewhere by introduction, but attempts to acclimate it south of its range have been largely unsuccessful.

This species lives under varied conditions, but usually in lakes, ponds, and quiet parts of streams, preferring cool to cold waters.

The only record known to me of its occurrence in bait tanks is of a single yearling picked up by R. D. Beland, on March 31, 1951, at Shorty's Bait Shop. According to testimony obtained by Mr. Beland (letter to author April 12, 1951), this specimen came from the holding ponds of A. G. Sessions at Marysvale, Utah.

The use of this species for bait is not recommended because yellow perch could become established in the river and experience elsewhere suggests that an overpopulation of stunted fish might result. If this were to happen the trout fishery in particular would suffer. Not only would the young compete with the young of other, more desirable species, but the adults, which eat fish, would compete with other adult fish and would prey on their young (Curtis, 1949, p. 269).

SCULPIN FAMILY (*COTTIDAE*)

The sculpins are fresh-water representatives of a predominantly marine family and are widespread in the northern hemisphere. They have broad, flattened heads and large pectoral fins and either lack scales or have few to many prickles, usually only behind the bases of the pectoral fins. They are bottom dwellers and eat algae, aquatic insects, fish eggs and fishes.

Bonneville Mottled Sculpin, *Cottus bairdi semiscaber* (Cope). Figure 2.

This species is distributed throughout the Bonneville basin and the upper Snake River. It is typically found in clear, cool, rapid streams over a bottom that varies from mud to loose rocks; it may also occur around lake margins.

On April 6, 1949, O. L. Wallis obtained one adult of this sculpin from the bait tank at Las Vegas Wash; it was also observed at the same time at the Lake Mead Boat Dock. Mr. Wallis was informed that the live bait with which this fish was associated came from Santa Clara River near St. George, Utah. No native sculpin has been reported, however, from farther down the Colorado River system than the headwaters of Fremont River, in south-central Utah. The most plausible source for this specimen is the Sevier River, where the Bonneville mottled sculpin is common and where bait fishes are known to be obtained.

Philip A. Douglas wrote (April 28, 1951) that on March 17, 1950, he saw what he is certain was a sculpin in Lake Havasu. The individual, appearing to be about six inches long, was lying on the rubble bottom in 18 inches of water approximately six feet off the first point south of the Needles Boat Landing. In its appearance and movements it closely resembled *Cottus bairdi*. No other such reports have come to my attention.

Sculpins are sometimes used as bait by anglers in various parts of the United States. Their use for this purpose along the Colorado River may be questioned because of the accusations that sculpins are predatory on trout eggs and young. However, a recent study (Zarbock, 1951) indicates little or no predation by this sculpin on trout eggs in the Logan River, Utah.

GOBY FAMILY (*GOBIIDAE*)

This is another group of typically marine species of small size that is almost worldwide in distribution. A few gobies occur in fresh water in the United States.

Longjaw Mudsucker, *Gillichthys mirabilis* Cooper. See Figure 3.

This species, which is the chief bait used by both salt-water and fresh-water fishermen in Southern California, attains a length of at least eight inches and is common in the bays and estuaries of Southern California and northwestern Baja California (Weisel, 1947, p. 77). It occurs northward in California to Mendocino County (Puget Sound records thus far checked by Isaac Ginsburg are not this species) and is represented at the head of the Gulf of California by *G. detrusus*, a very closely related species.

Mudsuckers were seen by our party at various places along the river in 1950, but few samples were preserved. Those observed at Kinder's Camp on April 7, 1950, were reported to come from Seal Beach, California, well within the range of this species. Bob Bolam (Needles Boat Landing) told me on June 15, 1950, that he used mudsuckers for bait up until three months prior to our visit. These came from San Diego and San Quintin, Baja California. On June 16, 1950, mudsuckers were sampled from the Lake Mead Boat Dock and were reported to have been "flown in from Mexico" (possibly from San Quintin, northwestern Baja California). These proved to be *G. mirabilis*. Mudsuckers were also seen at the Shell Oil Station in Pittman, Nevada, on June 16, 1950, but were not sampled. The dealer told me that these came from Long Beach; if so, they were this species. The Pittman dealer was then selling 100 per week to Bud Sunderland, a dealer just below Davis Dam.

Mr. Sidney Peritz of San Diego, who traps *Gillichthys* for the live-bait industry, told Carl L. Hubbs on May 31, 1950, that he had about 30

Mexicans trapping mudsuckers in San Quintin Bay, northwestern Baja California, and that the fish are flown to Del Mar, California. They are kept in large wire containers in the slough near the Del Mar airport, from which orders are flown out to the Colorado River and elsewhere. Mr. Peritz reported that the dealers gradually diminish the salt content of the water in which the mudsuckers are kept until it is entirely fresh, in which medium *Gillichthys* will live for several weeks.

Gillichthys detrusus Gilbert and Scofield, described from near the mouth of the Colorado River, has been reported (Evans and Douglas, 1950) as a bait fish along the Colorado River and from Salton Sea, California. However, Dr. Carl L. Hubbs, who indentified these samples, wrote to W. A. Evans (August 8, 1951) that he has reidentified most of the specimens as *G. mirabilis* (using the key character worked out by Isaac Ginsburg; see p. 10). The specimens picked up at the pelican rookery in Salton Sea are *G. detrusus*, but it has been concluded that the pelicans fed at the head of the Gulf of California or in the tidal part of the Colorado River and thus flew in the dead specimens reported by Evans and Douglas (1951, p. 436). Consequently there is no basis at this time for the inclusion of *detrusus* in the Californian fauna. Figure 3 was drawn when the records of the Gulf mudsucker were unquestioned, but it will serve equally well as an illustration of the longjaw mudsucker.

Attempts to propagate this fish for bait are being made and should be thoroughly explored and encouraged. If a successful method can be devised, the mudsucker may become one of the most valuable bait fishes along the Colorado River and elsewhere. Without propagation, the drain on the natural populations of this fish will presumably lead to a take insufficient for commercial operations and hence result in the abandonment of the industry as a major undertaking. This species is now established in Salton Sea (letter of C. L. Hubbs to W. A. Evans, June 21, 1951) and may multiply sufficiently there to serve as an important source for replenishing bait stocks.

Since this species is able to live for some time in fresh water but cannot propagate there, it is particularly well suited for use as bait.

RECOMMENDATIONS

During the past 15 years, 31 species of fishes are known to have been utilized for bait along the Colorado River, from the vicinity of Lake Mead to Yuma. More than half of these are minnows and suckers which constitute the most popular group of fishes for bait. Only four of the 31 are recommended without reservation as desirable bait fishes under the present environmental conditions of this section of the river. These are: the Utah mountain-sucker, the golden shiner, the fathead minnow, and the longjaw mudsucker. Most of the remainder are regarded as having a neutral effect on the fishery or are believed to be potentially undesirable. However, there are three species, the Mexican banded tetra, Utah chub, and yellow perch, which should be strictly prohibited because their establishment in the drainage would be likely to cause irreparable harm to the fishery.

The introduction of species from foreign waters presents the possible establishment of parasites and diseases that could be harmful to the native or acclimated fishes. Viewed in this light, any introduction is potentially harmful. The variety of habitats along the lower Colorado River, such as

the reservoirs, the cold-water tail races below dams, the oxbow lakes and the irrigation canals, makes it possible for some species to become locally established without affecting the fishery as a whole. Thus it is not easy to predict whether a given kind will or will not beome acclimated to some part of the drainage system.

It is not in their own interest for bait dealers to carry on or encourage practices that may lead to the introduction of deleterious species or which will deplete sources of supply beyond the recovery point. The fishery that is now established and steadily increasing along the river must be subjected to sound, long-time management practices if a major economic asset is not to vanish as rapidly as it arose. The interested states should agree on a selected number of species which appear to be wholly safe for use as bait fishes, and then encourage the propagation and distribution of these kinds. The local rearing of a few bait fishes should supply the needs of anglers and would then make it unprofitable to ship in mixed fish, some of potential harm.

REFERENCES

Breder, C. M., Jr.
1943. A note on erratic viciousness in *Astyanax mexicanus* (Phillipi). Copeia, no. 2, p. 82-84.

Bulletin of Zoological Nomenclature
1950. International rules of zoological nomenclature. Bull. Zool. Nomen., vol. 4, 760 p.

Curtis, Brian
1949. The warm-water game fishes of California. Calif. Fish and Game, vol. 35, no. 4, p. 255-273, 1 fig., 10 pls.

Davis, H. S.
1940. Laying the foundations of fishery management. Prog. Fish-Culturist, no. 50, p. 1-13, 13 illus.

Dill, William A.
1944. The fishery of the lower Colorado River. Calif. Fish and Game, vol. 30, no. 2, p. 109-211, 37 figs.

Evans, Willis A., and Philip A. Douglas
1950. Notes on fishes recently introduced into Southern California. Calif. Fish and Game, vol. 36, no. 4, p. 435-436.

Gilbert, Charles H., and Barton W. Evermann
1894. A report upon investigations in the Columbia River basin, with descriptions of four new species of fishes. U. S. Fish Comm., Bull., vol. 14, p. 169-204, 6 pls.

Gilbert, Charles Henry, and Norman Bishop Scofield
1898. Notes on a collection of fishes from the Colorado basin in Arizona. U. S. Nat. Mus., Proc., vol. 20, p. 487-499, 4 pls.

Hazzard, A. S.
1936. A preliminary study of an exceptionally productive trout water, Fish Lake, Utah. Amer. Fish. Soc., Trans., vol. 65 (1935), p. 122-128, 1 fig.

Hubbs, Carl L., and Laura C. Hubbs
1947. Natural hybrids between two species of catostomid fishes. Michigan Acad. Sci., Arts and Letters, Papers, vol. 31, p. 147-167, 2 figs.

Hubbs, Carl L., Laura C. Hubbs, and Raymond E. Johnson
1943. Hybridization in nature between species of catostomid fishes. Univ. of Michigan, Lab. Vert. Biol., Contribution no. 22, 76 p., 8 figs., 7 pls.

Hubbs, Carl L., and Robert R. Miller
1948. The zoological evidence: Correlation between fish distribution and hydrographic history in the desert basins of western United States. *In* The Great Basin, with emphasis on glacial and postglacial times. Univ. of Utah, Bull., vol. 38, no. 20 (Biol. Ser., vol. 10, no. 7), p. 17-166, 20 figs., 1 map.

Jordan, David Starr
1891. Report of explorations in Colorado and Utah during the summer of 1889, with an account of the fishes found in each of the river basins examined. U. S. Fish. Comm., Bull., vol. 9 (1889), p. 1-40, 5 pls.

Madsen, M. J.
1935. A biolobical survey of streams and lakes of the Coconino National Forest, Arizona. U. S. Bur. Fish., Mimeographed Rept., 21 p., May, 1935. (On file with U. S. Fish and Wildlife Service, Washington, D. C.)

Miller, Robert R.
1945. *Snyderichthys*, a new generic name for the leatherside chub of the Bonneville and Upper Snake drainages in western United States. Journ. Washington Acad. Sci., vol. 35, no. 1, p. 28.

1946. Distributional records for North American fishes, with nomenclatorial notes on the genus *Psenes*. Journ. Washington Acad. Sci., vol. 36, no. 6, p. 206-212.

Miller, Robert R., and Ralph G. Miller
1948. The contribution of the Columbia River system to the fish fauna of Nevada: Five species unrecorded from the state. Copeia, no. 3, p. 174-187, 1 map.

Moffett, James W.
1943. A preliminary report on the fishery of Lake Mead. Eighth North Amer. Wild. Conf., Trans., p. 179-186.

Murphy, Garth I.
1948. Notes on the biology of the Sacramento hitch (*Lavinia e. exilicauda*) of Clear Lake, Lake County, California. Calif. Fish and Game, vol. 34, no. 3, p. 101-110, 7 figs.

Simon, James R.
1946. Wyoming fishes. Wyoming Game and Fish Dept., Bull. no. 4, 129 p., 92 figs., 1 pl.

Wallis, Orthello L.
1951. The status of the fish fauna of the Lake Mead National Recreational Area, Arizona-Nevada. Amer. Fish. Soc., Trans., vol. 80 (1950), p. 84-92.

Weisel, George F., Jr.
1947. Breeding behavior and early development of the mudsucker, a gobiid fish of California. Copeia, no. 2, p. 77-85, 10 figs.

Zarbock, William M.
1951. Age and growth and food habits of the sculpin, *Cottus bairdii semiscaber* (Cope) in the Logan River, Utah. Utah State Agr. Coll., Coop. Wildlife Res. Unit., vol. 16, no. 2, p. 42-43 (abstract; mimeographed).

MECHANICAL AIDS FOR BIRD BANDING[1]

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Many thousands of birds, especially waterfowl and pen-reared game birds, are banded each year with conventional aluminum bands. These bands, individually numbered, come from the factory threaded on string or wire. This type band must first be opened enough to slip over the tarsus of the bird, then closed again. The task of keeping the bands in order as they are used is not a small one where large numbers of birds are banded. Uniform spreading of bands is usually accomplished only with difficulty. A few devices for keeping the bands in order have been described in banding manuals ("Manual for Bird Banders" by Frederick C. Lincoln and S. Prentiss Baldwin, U. S. Dept. Agriculture, Misc. Pub. No. 58, Nov., 1929, and subsequent issues), but little has been published on how to spread bands conveniently and uniformly. The usual method has been to open the bands with long-nosed pliers as they are taken from the string. Anyone who has used this procedure, especially on thousands of the larger-sized bands, has probably realized the need for a more efficient method. The devices described in this paper were developed to meet this need, and also with the idea of incorporating a band expander on the band holder or on the banding pliers.

To spread the bands easily required pliers with a reversed pivot action or some device which would convert the closing action of conventional pliers into a spreading action that would open the bands. Utica "horseshoe" lock-ring pliers No. 534 had the reversed action and were relatively easy to adapt. However, they were rather large for small-sized bands, necessitating the construction of smaller pliers by hand. The expander effect was also obtained by modifying two different types of banding pliers.

[1] Submitted for publication June, 1951. Federal Aid in Wildlife Restoration Act Project California 30-R. The drawings were prepared by Cliffa E. Corson.

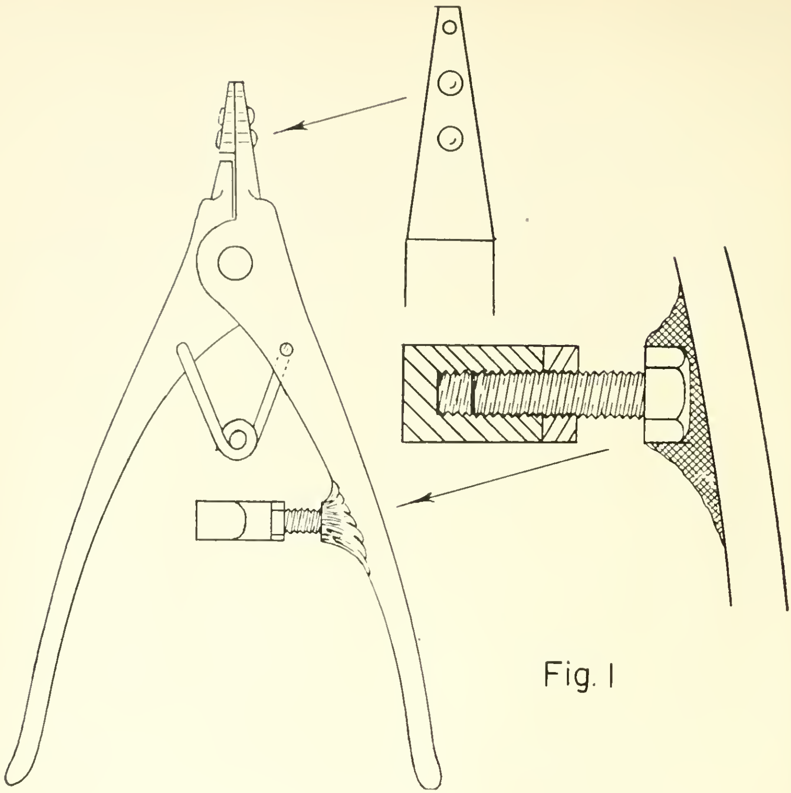

Fig. 1

TYPE A

Simple adaptation of the lock-ring pliers. It involves grinding down the jaws to the desired diameter of the bands to be used, riveting the jaws together, leaving a drilled hole at the tip, and sawing one jaw in two at a distance above the shoulder equal to the width of the band to be used. The cord or wire on which the bands are threaded is attached to the pliers through the hole in the tip. The bands and pliers can be suspended at a convenient level. A safer method is to braze the pliers to a small steel cable of the proper length. The cable should be brazed at the distal end and drilled with a $\frac{1}{8}$-inch drill. The bands can then be strung on the cable and a shower curtain ring, or some other device, used to lock them on. To prevent the over expansion of the bands, an adjustable stop is advisable. This can be made from a one-inch length of $\frac{5}{16}$-inch steel rod drilled and tapped for a $\frac{3}{16}$-inch machine bolt as shown in Figure 1. A $\frac{3}{16}$-inch bolt, $1\frac{1}{4}$ inches long is then welded to either of the handles. The use of a lock nut is also advisable. The stop can be of the nonadjustable type if only one size band is to be used.

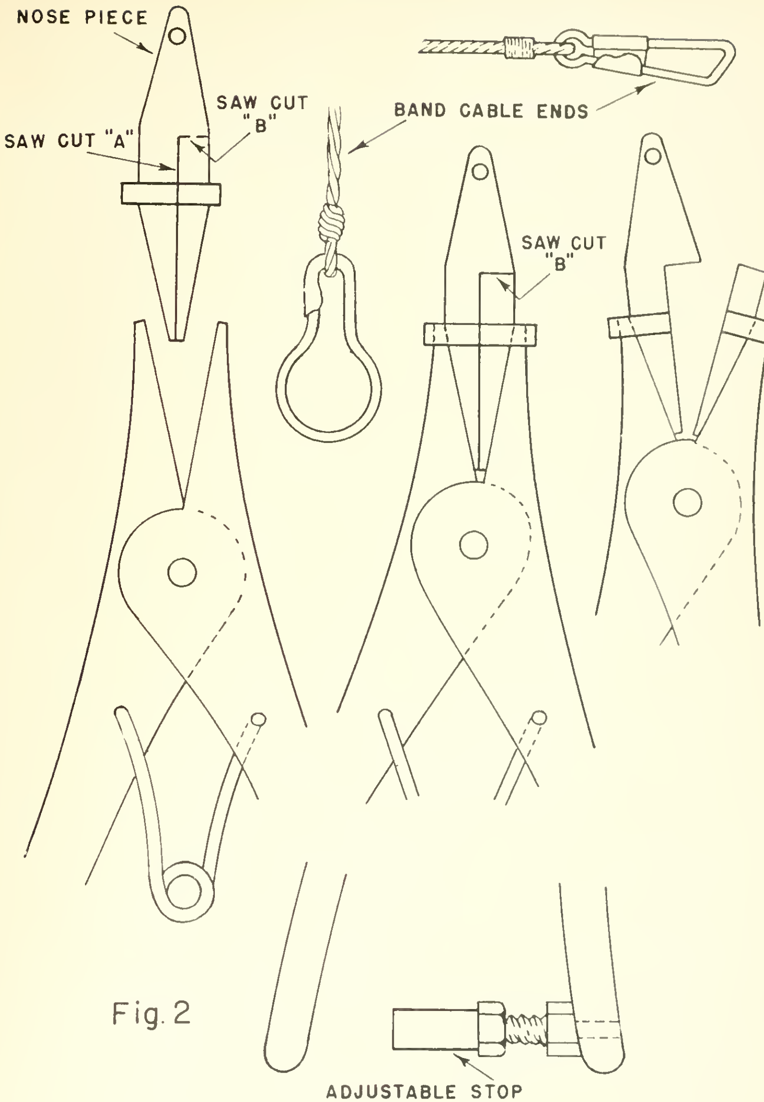

Fig. 2

TYPE B

A more elaborate modification of the Type A band spreader. The nose-piece is made by turning down on a lathe a length of $\frac{3}{4}$-inch, cold-rolled steel rod to a size just smaller than the inside diameter of the bands to be used. Leave the shoulder as illustrated, then cut and taper the ends as indicated. The tip is drilled with a $\frac{1}{8}$-inch drill, while the taper on the opposite end is flattened to fit the jaws of the pliers. Saw cut A is then made, the depth of the cut being determined by the width of the band to be used. The jaws of the pliers are welded to the nose-piece and the action is freed by making saw cut B. The cable can be attached with a fishing lure snap if it is desirable to switch from one band series to another.

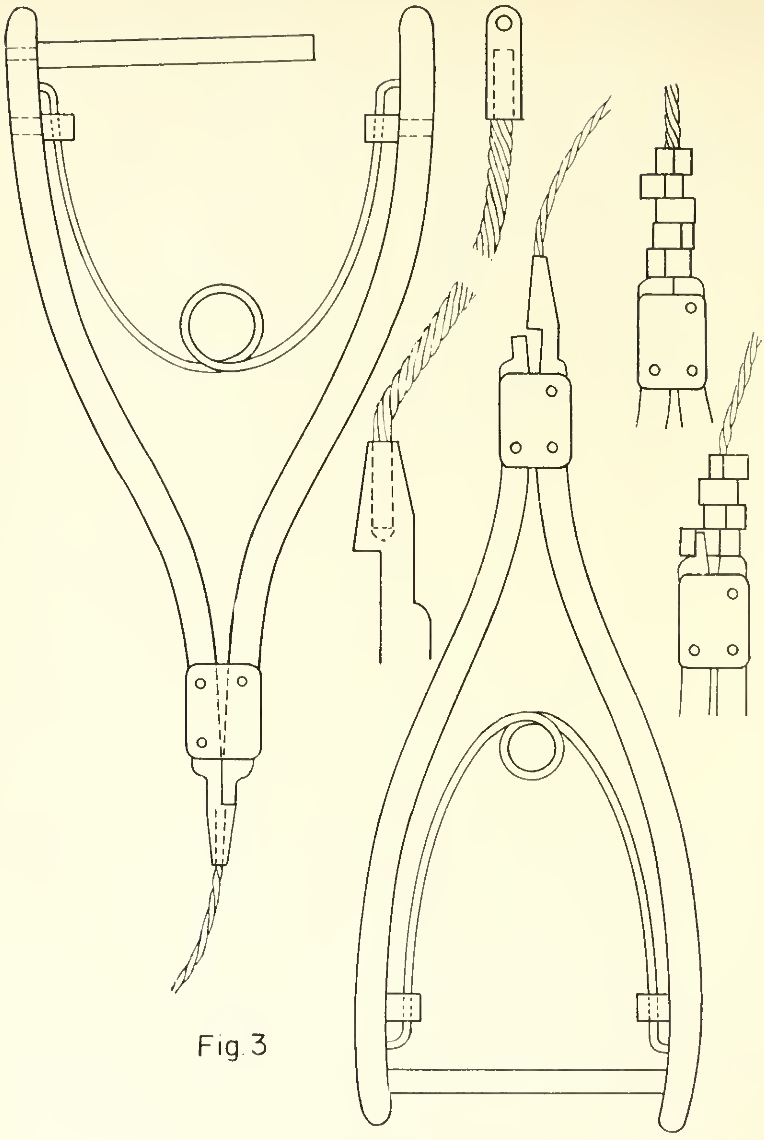

Fig. 3

TYPE C

A band spreader to accommodate quail bands. The pliers must be hand-made. This can be done by sawing transversely a six-inch length of steel rod, ½-inch in diameter. Two plates are riveted to one handle to form the pivot, while the feed cable is soldered into the drilled receptable in the tip. The length of the tip on the opposite jaw, which expands the band, should be equal to approximately one-half the width of the band to be used. A longer tip tends to twist the small bands as they are opened. The distal end of the feed cable is also brazed to the cap.

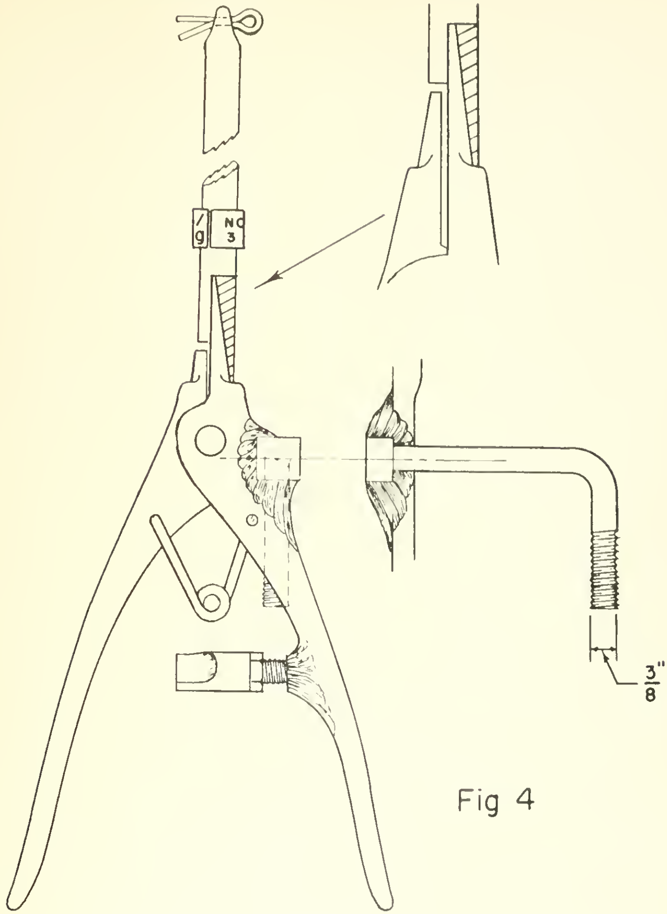

Fig 4

TYPE D

Self-supporting band spreaders with a steel rod to hold the bands instead of a flexible cable. The pliers are modified by grinding down the jaws to the desired diameter for the bands to be used, leaving abrupt shoulders for band stops. One jaw is cut off a width of a band above the shoulder and the other is fitted to the groove cut in the rod that is to be brazed to the pliers to accommodate the bands. When the two are brazed together, the difference in thickness of the tapered jaw and the rod is filled with solder. The excess solder is removed and the remainder is smoothed and shaped with a file. For a No. 6 waterfowl band, the rod should be about $\frac{5}{16}$-inch in diameter, and approximately 40 inches long. Cold-rolled steel should be used. A $\frac{3}{8}$-inch bolt 7 inches long with a right-angle bend is welded to the plier handle near the pivot. The band spreader can then be attached to some support. A convenient support can be made by welding a $\frac{3}{8}$-inch iron pipe nipple to a light weight steel post 4 feet long. The post can be pushed into the earth to the desired depth and the bolt on the band spreader slipped into place. A multiple mount can be made by welding to the post a cross-piece to which have been brazed three or four $\frac{3}{8}$-inch pipe nipples.

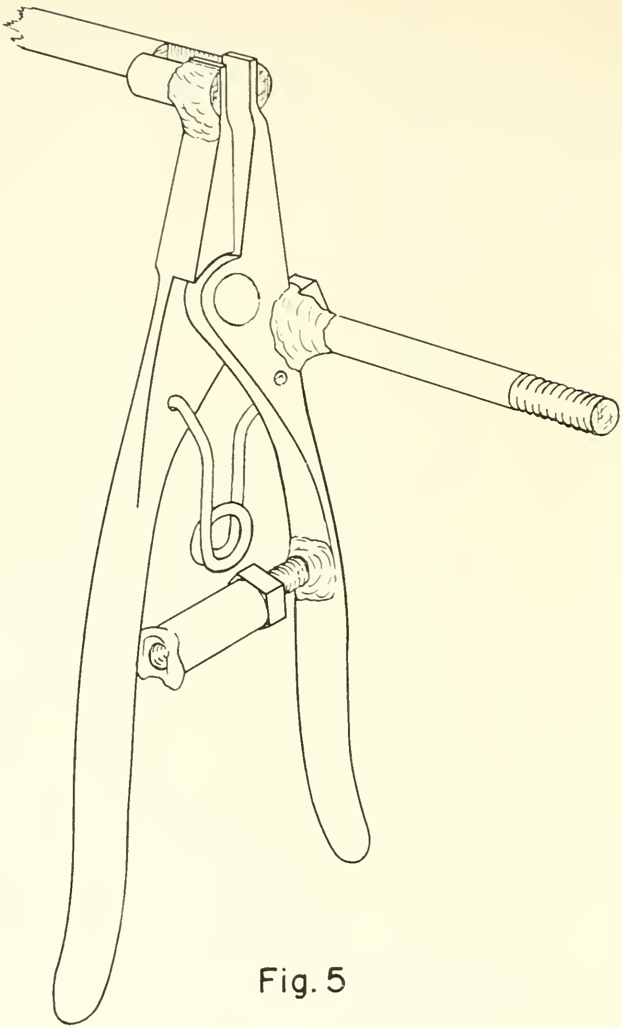

Fig. 5

TYPE E

Modification of Type D band spreader. This type is quite similar to the one just described except that the pliers are attached at right angles to the rod which holds the bands. The spreading action obtained by this arrangement works well with the larger sized bands, as the tip which opens the bands remains parallel to the feed rod as the jaws are opened. The feed rod may be of cold-rolled steel, or of steel pipe for lighter weight. The pliers are brazed on after one end of the rod has been cut and ground to fit as indicated in Figure 5. An expander tip formed to fit over the jaw, which will fill the recess cut in the feed rod, is brazed to the free jaw. A $\frac{3}{8}$-inch bolt 3 inches long is welded to the stationary jaw. With this bolt the spreader can be attached to the same standard described for Type D.

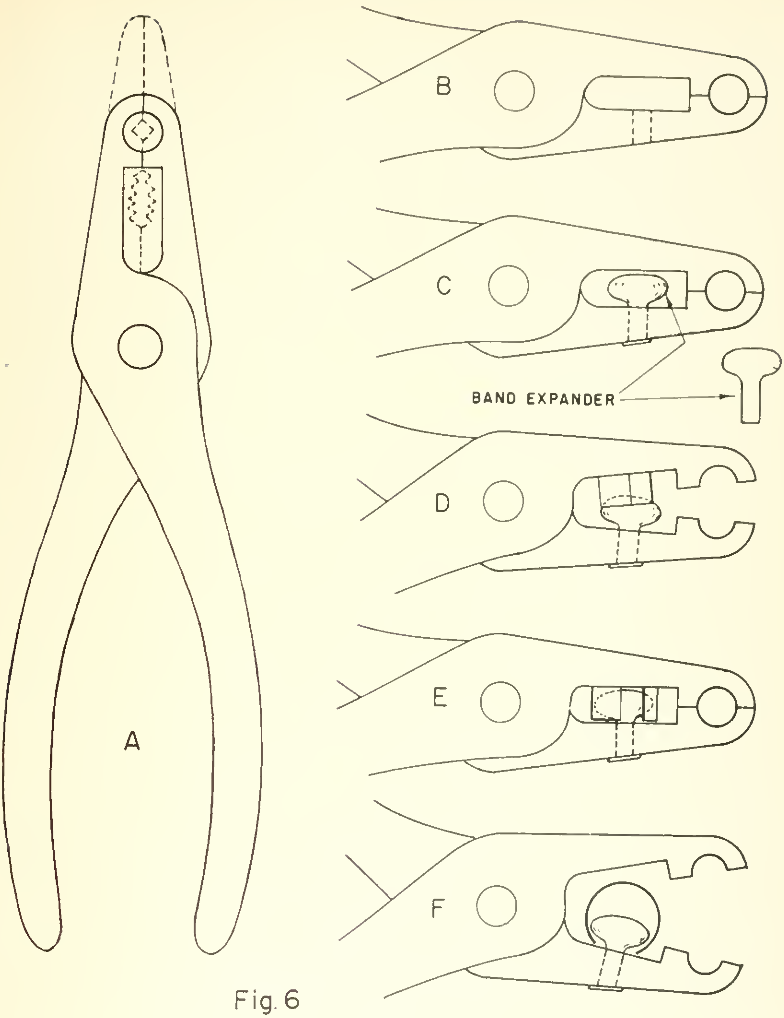

Fig. 6

TYPE F

Band spreader for small game bird bands. This tool was developed for opening and closing the small bands such as the Fish and Wildlife Service No. 4 band, and for quail bands. P. and C. #1260 telephone pliers were modified to make these banding pliers. Diagram A shows the original pliers; B shows the jaws cut down and ground out properly. The hole bored in the jaws to facilitate closing the bands should be drilled with a bit of the same size as the outside diameter of the bands to be used. The jaws should be held apart approximately $\frac{1}{32}$-inch with a shim while being drilled. This imparts a slightly oval shape when the jaws are closed completely, and enables the bands to be closed securely. In diagram C the band expander is illustrated. The door-knob shape is necessary to permit the easy removal of the opened band. It is inserted into a hole drilled in the jaw and riveted into place. The remaining diagrams in Figure 6 illustrate the operation of the pliers in opening bands: D, band in position for opening; E, band opened as the pliers are closed; F, band turned up so it will drop off the expander.

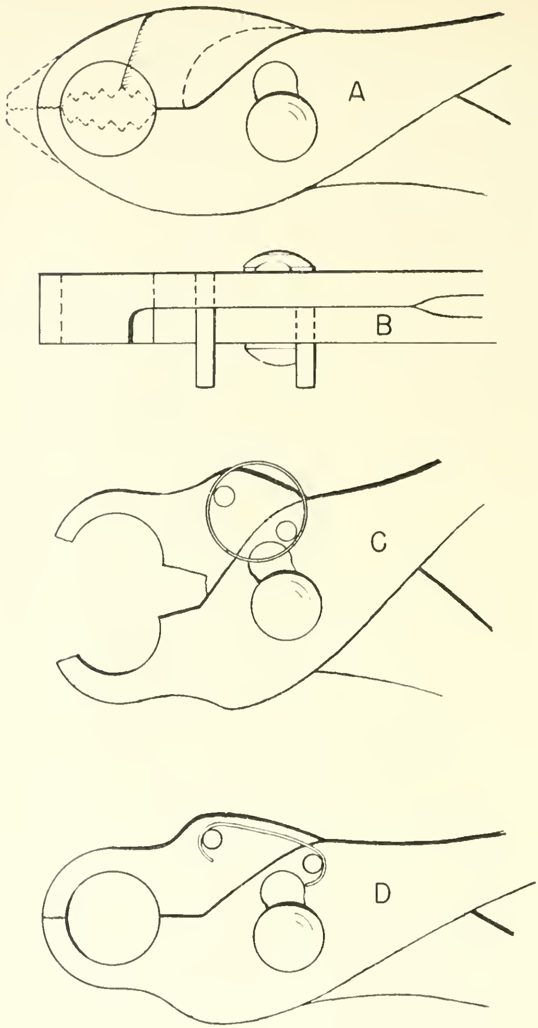

Fig. 7

TYPE G

Pair of banding pliers modified to spread bands as well as close them. "A" shows the jaws of the slip-joint pliers before alteration; B, the top view of the finished product; and C and D, the position of the jaws at different stages of the spreading operation. The peg positions will vary with different makes of pliers and should be located so the band will not be opened too much when the pliers are completely closed. Grinding the pliers near the short peg is sometimes necessary in order to get the pegs to come close enough together to receive the closed band. The closing action of the pliers gives best results when the aperture in the jaws is bored out slightly oval.

DISCUSSION

Upland game birds and waterfowl can be banded much more efficiently when tools are used which will not only hold the bands in order, but will also spread them. Types A, B and C, which have flexible feeder cables, can be rolled up and carried very easily. They are best adapted for use where only a few bands are used at one time. Types D and E with the rigid feeder rod and supporting staff are best adapted for large-scale banding operations when a considerable number of birds is banded at one site. Banding pliers which are capable of being used to open bands as well as close them have a decided advantage. Band spreader types F and G have this quality and expand the band with the closing action of the pliers.

These banding tools have been used in the field and found to be of merit. Their cost varies, but in general, they are relatively inexpensive. In 1950, the "horseshoe" type lock-ring pliers retailed at approximately $2.20 per pair, the telephone pliers at about $1.50 per pair, and the slip-joint pliers at about $1. The cost of the types D and E band spreaders when constructed singly at a machine shop was less than $6 per pair. With the possible exception of the handmade quail band spreaders, the cost of the other types ran considerably less.

STOPPING THEM: THE DEVELOPMENT OF FISH SCREENS IN CALIFORNIA[1]

By EARL LEITRITZ
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Drawings by CLIFFA E. CORSON

The line curls out across the fast water, the leader turns over, and the well placed fly swings around with the current. Then a jarring strike! Your line tightens, the rod bends, the reel sings, and now it is up to you to stop that silvery streak. The trout leaps in a shower of spray. Again and again he runs. Then as he tires you lead him up close to your side. Once again he tries to break away but now his efforts are feeble. One last swirl and you lead him into your net. You have stopped him! Stopped him for the last time! As a fingerling, though, this fighting rainbow may have been stopped before—but in a somewhat different manner—perhaps by a screen in a hatchery trough, at a powerhouse intake, or irrigation diversion.

Screening to prevent small fish from being lost had its beginning many years ago. In 1865 Mr. Seth Green used a mechanical device at Caledonia Creek, New York, to prevent fish from running from his pond up into the millpond above. This was merely a water-wheel with paddles coming so close to the frame in which it revolved that it kept the fish from ascending. This was really a primitive "screen," and since then many decidedly different types of contrivances labeled as fish screens have been evolved.

Fish screens are highly specialized structures which are not easily made or maintained by unskilled individuals. The main difficulty has been to find a satisfactory mechanical device which would keep small fish from entering the ditches, and at the same time would not interfere with the required flow of water even when the water was laden with debris. A most important point in the installation of any screen in a diversion canal is that a by-pass with sufficient water be provided so that the fish stopped by the screen can return to the natural channel. It is useless to stop migrating fish at a screen without giving them a chance to proceed on their downward course. Only a small amount of water is required for a by-pass, but that small amount is absolutely essential. In addition to these requirements, a screen should be designed to demand a minimum of repair and constant maintenance. All of the requirements as to mechanical design have not yet been fully met. Many of the early screens were unsatisfactory and this has at times brought a resistance to the program. The development has been discouragingly slow but new materials and designs have now enabled the construction of screens which far outstrip their predecessors.

[1] Submitted for publication June, 1951.

Much of the developmental work has taken place in California, where since early days the Fish and Game Commissions have struggled with the difficult problem of screening diversions to prevent the loss of trout and salmon. Our most recent invention is the self-cleaning perforated plate screen, which has several advantages over screens formerly used.

The following drawings and discussions have been prepared to illustrate the relative merits of most of the fish screens which have been used in California. They represent the work of many men and demonstrate the ingenuity with which man has sought to preserve his fishery resources.

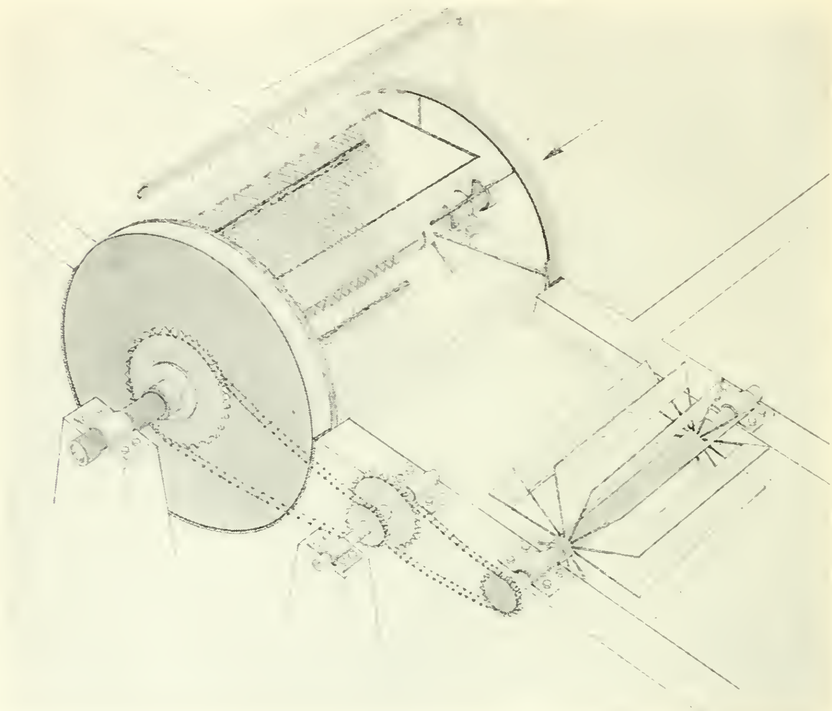

FIGURE 1

INTERNAL SPRAY-CLEANED FISH SCREEN

This screen was designed to remove debris from a hatchery water supply. Water flows into the open end of the slowly revolving screen, which is chain-driven by a paddle-wheel and slowly rotates upon a hollow shaft. A hopper attached through a slot opening into the hollow shaft catches and diverts debris and other fine particles through the hollow shaft away from the installation. The bell-shaped hopper has a large opening near the top and extends the full length inside the screen. A pressure water pipe having a series of small jets is mounted directly above and parallel to the screen. These jets force water through the screen. In this way the foreign particles are washed from the screen into the hopper.

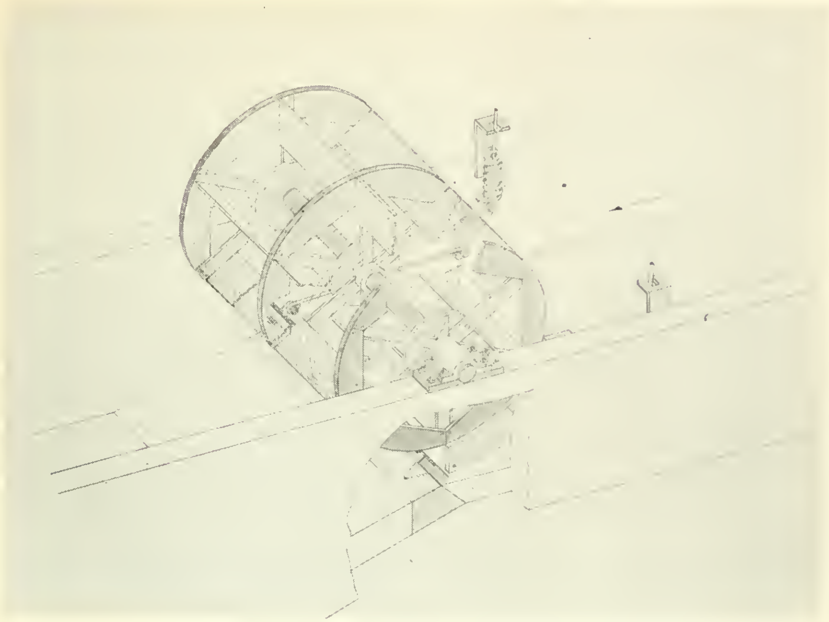

FIGURE 2

CALIFORNIA ROTARY FISH SCREEN

This screen is a very early development, and is a feeble attempt at stopping fish. It was at one time the approved type of fish screen for installation in California diversions. The rotary cylinder contains the paddle-wheel. The paddle-boards actually form a portion of the framework for the screen cylinder. The screen rotates in a direction which forces debris under it rather than over the top. In an attempt to make it fish-tight, yet allow for debris to pass under it, it was equipped with a hinged draper board at the bottom, the board being held against the screen by springs. It was intended that when an accumulation of debris lodged against the draper board, pressure would be built up to the extent that the board would swing downstream sufficiently to free the debris and then snap back into position. But if only a small twig catches between the draper board and the screen cylinder, fish escape quite easily. Its effectiveness: zero!

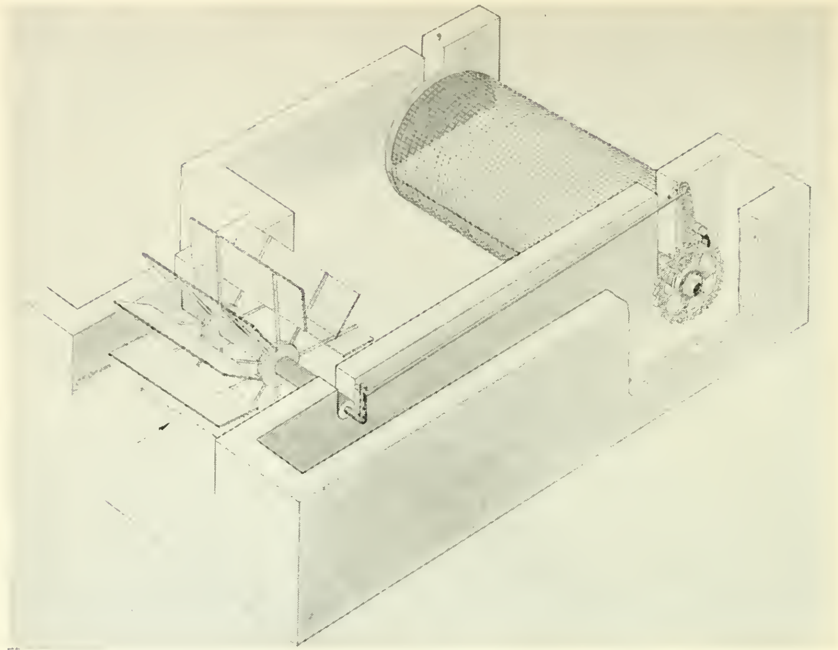

FIGURE 3

REQUA FISH SCREEN

This rotary screen is also an early development. The screen is paddle-wheel driven through a pawl and ratchet wheel. The screen moves intermittently. The distance the cylinder travels each time the rachet is engaged is governed by the length of the crank arm on the paddle-wheel. This screen has been widely used in rearing and brood ponds at California hatcheries. Under conditions where it receives constant observation and where repairs and adjustments can be made on the spot, it has proved quite satisfactory. Its main weakness is excessive wear to the pawl and ratchet wheel which is partly submerged. It is also difficult to prevent fish from running up from the lower side and becoming injured by the paddle-wheel. For efficient operation of any cylinder-type rotary screen, it is necessary that the water level on the upstream side of the screen be up to or above the axle or center line of the screen.

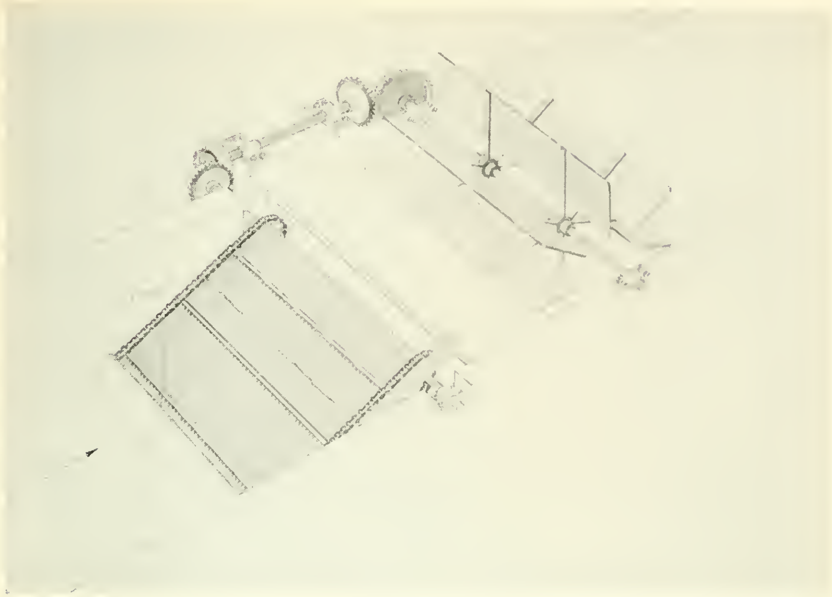

FIGURE 4

PARALLEL BAR SCREEN WITH CLEANER

This is a self-cleaning parallel bar screen. It is unique in that the bars are wedge-shaped, and the spacing between each bar is narrowest at the upstream side, with the space increasing and tapering toward the downstream side. This affords greater opportunity for particles passing through the bars to free themselves and prevent clogging. While this principle may seem to have some merit, it is next to impossible to make this screen fish-tight. The cleaning mechanism must pass up the front side with its wiper bars and down the back side as an endless chain. It is therefore necessary to have a flexible seal at the bottom edge which will permit the cleaning mechanism to operate. The bottom seal is a very weak part of this screen, since small fish are usually able to escape around or under it. The lower shaft and gear arrangements which are completely submerged and rest near the bottom wear rapidly, due to the abrasive sediment carried by water. There is no pressure exerted by the wiper bars other than their weight riding on the screen surface, and usually the wiper bars rise sufficiently to ride over accumulations on the screen rather than to carry them over. Several of these screens were installed in California diversions, but in each instance proved ineffective.

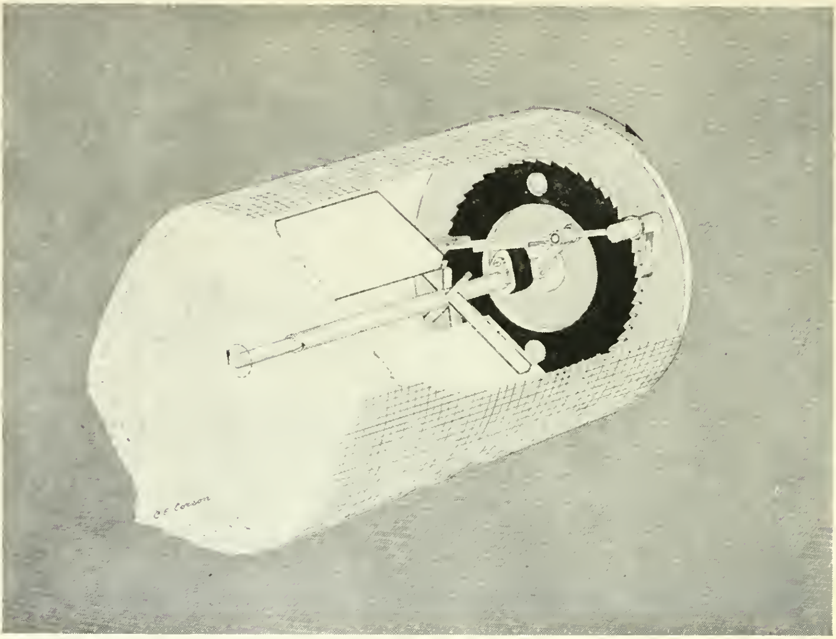

FIGURE 5. Murray inner drive rotary fish screen

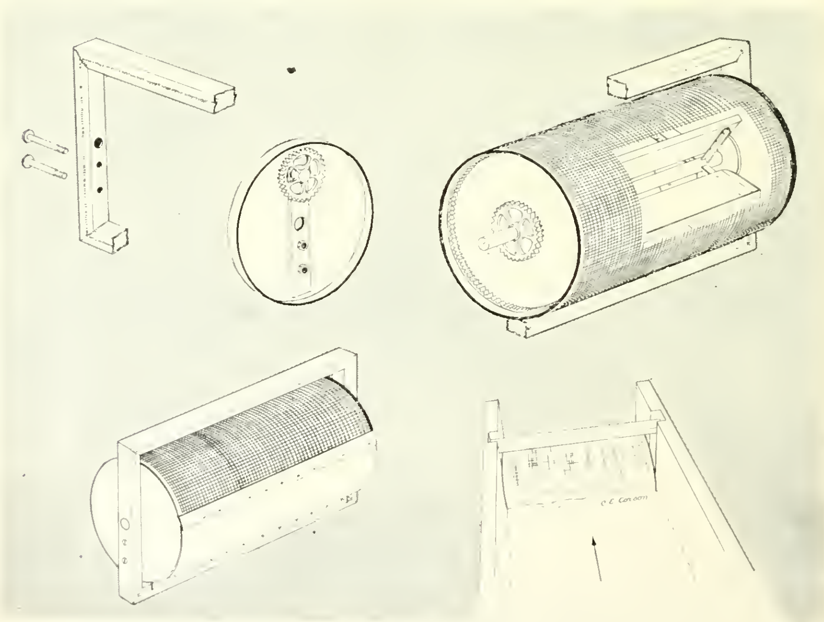

FIGURE 6. Saunders inner drive rotary fish screen

Basically, the screens shown in Figures 5 and 6 are the same. They are of the rotary cylinder-type with enclosed paddle-wheel which causes the screen to rotate against the current while the paddles turn with the current. About the only difference is in the operating mechanism. One uses a pawl and ratchet with cam and lever arrangement which causes the cylinder to rotate intermittently, while the other utilizes a direct gear drive with intermediate gear between the shaft and ring gear, causing constant rotation of the cylinder. The gear-driven screen is commercially manufactured which is of considerable advantage since many hatcheries are not equipped to manufacture fish screens. This screen is well designed and is constructed of durable materials. The shaft and ring gear are of stainless steel; the intermediate gear and all bearings are of Micarta, insuring long life when water-lubricated. Screen material is of hi-carbon steel, making it very rigid, and is galvanized after weaving. The screen is mounted in a single metal frame which slides down into slots in the side of the screen box, which makes it easily adjustable to any height. It can be removed by simply lifting it from the screen box. This screen has proved very effective at fish hatcheries for installation between raceways or hatchery ponds. It will operate with a drop of four inches or less between ponds. It is impossible for this screen to injure fish because the paddle-wheel is enclosed. It is a simple matter to seal around the cylinder and make it fish-tight.

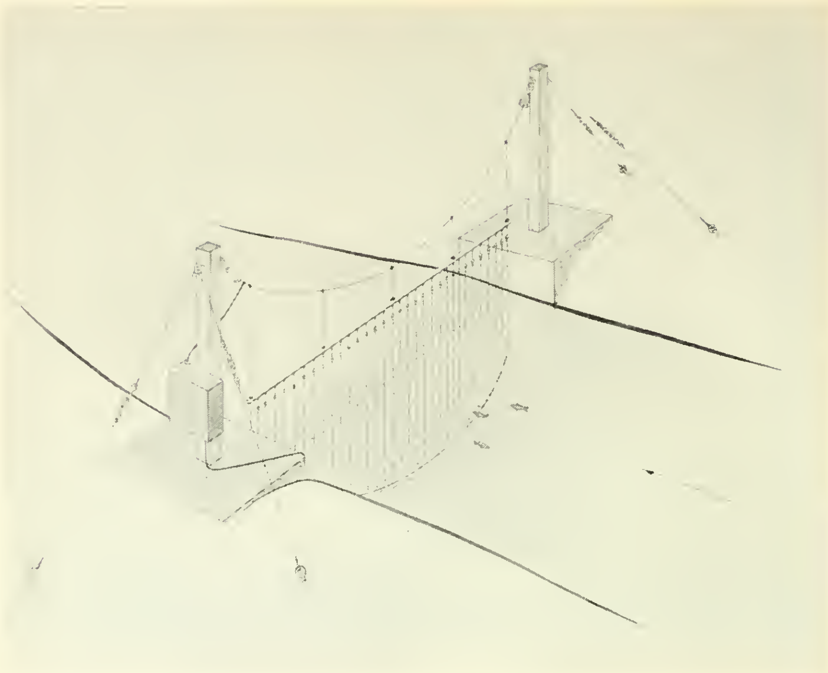

FIGURE 7

ELECTRIC FISH SCREEN

The electric fish screen may actually be termed an electric fence. It consists of a group of suspended electrodes which swing with the current and remain fairly free of obstructions, a ground electrode lying on the stream bottom forward of the swinging electrodes, and an electric impulse generator located on the bank nearby. The electric generator produces electric impulses which can be varied in strength and duration and are effective in charging an area and administering mild shocks to fish which attempt to pass between the electrodes. While the electric fish screen may be somewhat effective when installed at the entrance to large canals where only a small portion of the water is diverted from the main channel, it is subject to power failures and cannot be installed in areas where electricity is not at hand. The stream area actually charged by the shocking waves is relatively small, and any fish with a burst of speed or a desire to run through the charged area can do so without receiving anything other than a mild shock. If the current is too rapid, fish may also be carried through the electric screen against their will.

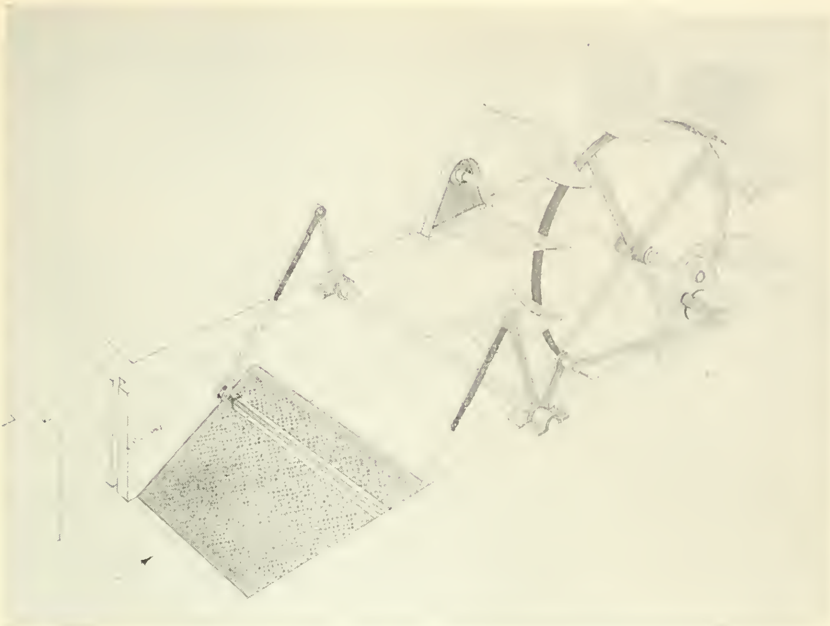

FIGURE 8

MURPHEY PERFORATED PLATE FISH SCREEN

This perforated plate screen with mechanical wiper bar is the latest development in fish screens in California. It has been experimented with for over three years and offers great promise. It is designed for and is being used primarily in irrigation diversions. Basically, this screen consists of a perforated metal plate with circular openings of $\frac{5}{32}$-inch diameter. The plate, having about 46 percent open area, is placed in the screen box at an angle of approximately 32 degrees. A wiper bar travels up and down over the surface of the plate much like the blades on a windshield wiper, except that the blades do not swing in an arc, but rather move up and down the full length of the plate. Power for operating the wiper bar is usually obtained from a large diameter paddlewheel set behind the plate. Several different types of driving mechanisms have been developed. A direct drive from the crank arm on the paddlewheel is practical for small irrigation ditches, while a more powerful drive using a reduction gear is better suited for large diversions. If desirable, the wiper bar may be operated directly by an electric motor. At one installation, a hydraulic drive using a double-action hydraulic cylinder driven by a one-quarter horsepower motor is used. This small motor and hydraulic cylinder operate wiper bars over three perforated plates, each plate being $5\frac{1}{2}$ feet wide and 12 feet long. A revolutionary feature of this new screen is the wiper bar, which has a hard sharp edge and is designed to cut underneath the debris on both the upstroke and the downstroke. It has been found that this bar when pushed down across the face of the plate carries the debris ahead of it until it reaches the unperforated margin along the lower edge of the plate.

There is no current through this unperforated edge, and the flowing water strikes it, sweeping up and over the cleaner bar, carrying the debris with it. The material is then swept onto the upper edge of the cleaner bar, and when the bar is pulled back up against it, the debris is carried over the top of the plate. By using the perforated plate with this type of cleaner, it is possible to seal the bottom edge as well as the sides of the plate so that no fish are able to get under or around the plate.

REFERENCES

Spencer, John
1928. Fish screens in California irrigation ditches. Calif. Fish and Game, vol. 14, no. 3, p. 208-210.

Wales, J. H.
1945. A new fish screen for hatchery use. Ibid., vol. 31, no. 3, p. 157-159.
1948. California's fish screen program. Ibid., vol. 34, no. 2, p. 45-51.

Wales, J. H., E. W. Murphey, and John Handley
1950. Perforated plate fish screens. Ibid., vol. 36, no. 4, p. 392-403.

ESTIMATION OF FISH POPULATIONS IN A FLUCTUATING RESERVOIR[1]

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INTRODUCTION

In recent years a knowledge of the sizes of fish populations has become more and more essential for a basic understanding of both theoretical and practical fishery problems and their solutions. Particularly desirable is comparative information on the status of fish populations for both fished and unfished waters.

It is especially significant to note that the catch per California angler has been declining rapidly for many species of fresh-water fishes in both cold and warm waters (Calhoun, 1950, 1951). In California, the extent of the cold-water environment of streams and lakes cannot be expected to increase very much in the future. On the other hand, the extent of the warm-water environments has increased rapidly in recent years with the creation of many reservoirs. Because these reservoirs are potentially important in supporting fish populations which will aid in the maintenance of a satisfactorily high catch for anglers, their fish populations are in need of biological study *before* any drastic changes may take place as a result of fishing or questionable management practices.

At the present time most of the quantitative data on the sizes of fish populations are for smaller lakes and ponds, whose populations may be enumerated directly following poisoning or draining operations. For larger lakes and reservoirs indirect methods of population estimation must be utilized. Many of these techniques and their underlying assumptions are summarized by Ricker (1948). Unfortunately, few estimates are available for comparisons of populations under different conditions of environment and fishing pressure in the larger bodies of water, due principally to the considerable requirements of energy and facilities necessary for field operations in obtaining adequate and unbiased samples.

It is the purpose of this study (1) to set up an efficient field procedure with the minimum amount of equipment and labor in order to estimate the fish populations in a fluctuating reservoir, (2) to estimate the population sizes of several of the more prominent warm-water species which have been under the influence of negligible fishing pressure for a decade or so, and (3) to evaluate the problems of expressing the densities of the standing fish crops on an acreage basis.

The study was made possible by the kind cooperation of Mr. Ernst Brandsten, manager of the property on which Searsville Lake is located.

DESCRIPTION OF SEARSVILLE LAKE

Searsville Lake (Figure 1) is a small (98-acre) impoundment of a part of the San Francisquito Creek drainage in San Mateo County, California. The lake lies on the northeast periphery of the Santa Cruz Mountains

[1] Submitted for publication March, 1951.

at the approximate upper boundary of the Upper Sonoran Life Zone (Grinnell, 1935).

The initial impoundment was made in 1891 and was followed by several alterations of the dam and other parts of the lake in more recent years. The present dam height is 90 feet. Fluctuations in level have been severe in past years, the lake having been completely drained following the 1923-24 drought; fluctuations during the past decade or so have usually been within 10 feet below the spillway level. During the 1950 season the water level fell about 6½ feet from the spillway level. Silting is very heavy in the rainy season.

Descriptions of the macrobenthos and limnetic plankton with selected physical and chemical data have been compiled by Felin (1940) and Scott (1927).

Prodigious growths of rooted aquatic vegetation choke the shallower waters of the entire lake. Near shore the principal plants are bulrushes (*Scirpus* sp.), cattails (*Typha* sp.), and water smartweed (*Polygonum* sp.). From shore to a depth of about 12 feet, water milfoil (*Myriophyllum* sp.) grows profusely; the emergent portion of this species is frequently dense enough to support the weight of the larger aquatic birds. All these species follow the retreating shoreline as the water level recedes during the summer.

The present fish fauna of the lake consists principally of brown bullheads (*Ameiurus nebulosus*), black crappies (*Pomoxis nigromaculatus*), bluegills (*Lepomis macrochirus*), and largemouth black bass (*Micropterus salmoides*). Green sunfish (*Lepomis cyanellus*) and hitch (*Lavinia exilicauda*) are much rarer. The small mosquitofish (*Gambusia affinis*) occur abundantly in the shallow waters along the lake shore. Following the drainage in 1924 the lake was stocked only with 500 bass and an

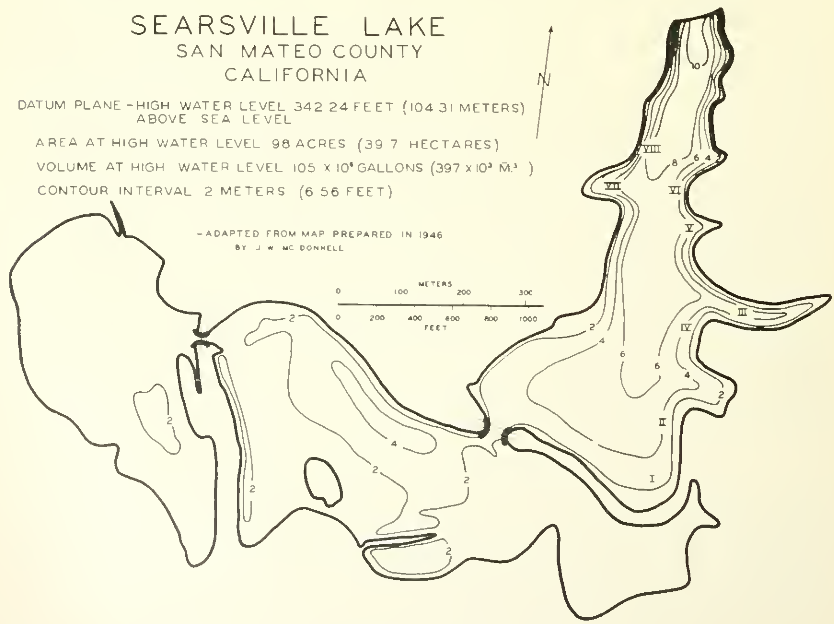

FIGURE 1. Map of Searsville Lake, San Mateo County, California

unknown number of bluegills and black crappies. The erstwhile abundant carp (*Cyprinus carpio*) population disappeared at the time of drainage, but it is possible that a few of the brown bullheads survived in some of the small mudpuddles which remained. The origin of the other extant species is not known with any degree of certainty.

In recent years there has been virtually no fishing in this lake, and the only mortality to which existing populations have been exposed may be classified as "natural" mortality.

METHODS AND MATERIALS

During the months of April and May in 1950 population estimates were carried out by the method of Schnabel (1938), a modification of the classical Petersen mark and recapture technique, based on an average of a series of estimates made while marking is in progress. The population estimate, P, for the entire series of periods of operation is

$$P = \frac{\Sigma\ (A\ B)}{\Sigma\ (C)}$$

where A is the total number of fish observed for each period, B is the total number of fish marked and at large at the time of sampling, and C is the number of marked fish recaptured in any one period. There were from five to seven periods, of one week or less, and the results of each period were summed as indicated in the formula.

Fish were taken only in one-inch mesh poultry wire traps (Figure 2). The traps were triangular in cross section, three feet on the side and four feet in length. Four No. 10 galvanized wire triangular hoops were used for support. The traps were enclosed at one end which was fitted with a door; the opposite funnel end had an opening of six inches. Attached

FIGURE 2. Fish trap constructed of one-inch galvanized poultry mesh and heavy wire

to each trap was a quarter-inch rope with a board float to mark the location of the trap. The traps were set unbaited parallel to the depth contours in water 4 to 12 feet deep.

Trapped fish were marked by clipping the left pectoral fin at its base. Each fish marked or recaptured was weighed and its length measured. In order to avoid the possibility of recapturing "trap susceptible" fish, the traps were kept in one location no longer than 24 hours.

Because of different intensities of trapping and marking efforts in the north and south sections of the lake, the tabulations of data were kept separate for each section. The more completely isolated west section of the lake was not studied.

In the north section of the lake, 8 to 16 traps were set at or near the sites indicated by Roman numerals in Figure 1. Five periods of marking, with each period representing approximately equal amounts of fishing effort, were utilized between April 2 and May 14, 1950; each period of marking was separated by several days to allow for a more random distribution of the marked fish.

In the shallow, weed-choked south section marking was carried out on the basis of 6 or 7 one-day periods of fishing distributed between April 15 and May 14, 1950; 8 to 16 traps were spaced over all but the most densely weeded areas.

RESULTS

Sufficient numbers of bullheads, black crappies, and bluegills in each section of the lake were marked for population estimates. Largemouth black bass, hitch, and green sunfish were too scarce in the trap catches to allow for adequate estimates of their population sizes. Confidence limits at the 0.95 level for each of the estimates were computed according to the Poisson approximation procedures developed by Chapman (1948). The average weights of the fish of each species were multiplied by the respective total populations to give an estimate of the total weights of the populations in the lake. The population estimates, their upper and lower limits at a confidence of 0.95, the average weights, and the total weights are summarized in Table 1 for the north and the south sections of the lake. On the basis of one recaptured largemouth bass in the north section the population was the obviously low figure of 85, with 0.95 limits estimated from about 18 to 1657; actually, the upper limit would probably be much more realistic.

For brown bullheads, black crappies, and bluegills the standing crops on a per-acre basis were computed for each section of the lake for the acreages at the high water level and for the acreages when the lake is drawn down six and one-half feet (two meters). These data are given in Table 2.

It should be noted that the traps were approximately equally effective in catching these three species in both the north and south sections of the lake.

DISCUSSION

The use of the triangular wire traps for sampling fish populations proved to be very successful. These traps have many advantages over other types of gear: they are very portable and may be handled easily and rapidly by one person; they may be set on steep slopes without

TABLE 1

Estimates of Population Numbers and Weights of Three Species of Fish in Searsville Lake, California, From April 2 to May 14, 1950. For Each Period, A = Number of Fish Handled, B = Number of Fish Marked at Large, and C = Number of Recaptured Marked Fish.

Location	Species	Number of periods	Number marked B	$\sum(A \cdot B)$	Number of recaptures $\sum C$	Estimated population P	0.95 confidence limits		Average weights (mgs.)	Total weights	
							lower	upper		kgs.	pounds
North section	Brown bullhead	5	867	897,108	85	10,554	9,733	11,493	134	1,414	3,118
	Bluegill	5	192	41,186	10	4,119	1,928	7,743	99	408	899
	Black crappie	5	271	40,874	9	4,542	2,023	8,870	83	377	831
South section	Brown bullhead	6	288	142,323	25	5,693	3,631	8,422	123	700	1,544
	Bluegill	7	23	1,330	2	665	102	3,752	99	66	145
	Black crappie	7	26	2,402	2	1,201	184	6,776	76	91	201

TABLE 2

Comparisons of the Standing Crops of Three Species of Fish in Two Sections of Searsville Lake on the Basis of Areas at High and at Low Water Levels. (See text.)

Location	Area at high water (acres)	Area at low water (acres)	Species	Pounds per acre at high water	Pounds per acre at low water
			Brown bullhead	89.3	104.3
North section	34.9	29.9	Bluegill	25.8	30.1
			Black crappie	23.8	27.8
			Totals	138.9	162.2
			Brown bullhead	38.7	132.0
South section	39.9	11.7	Bluegill	3.6	12.4
			Black crappie	5.0	17.2
			Totals	47.3	161.6
West section	23.2	1.0			

danger of rolling into deep water; they may be set in regions of dense aquatic vegetation; they are relatively unselective of sizes of fish above the minimum size which traps can catch; they catch fish efficiently in large numbers; they do not damage fish to any extent; they are inexpensive.

The size range of the bullheads was from 6 to 14.5 inches total length; the range of the bluegills was from 4 to 9.5 inches total length; and the range of the crappies was from 4 to 14 inches total length. None of the three species was known to exist in any larger sizes than were taken by the traps. Population estimates accordingly apply to these indicated size ranges. The few largemouth bass taken during the course of the sampling ranged from 6 to 21 inches in total length, indicating also that the traps effectively sampled the larger fish.

A distinct disadvantage of the traps is that they sample fish only at or near the bottom. This feature undoubtedly accounts for the relative abundance of the demersal bullheads, the relative scarcity of the more pelagic bluegills and crappies, and the rare occurrence of bass in the samples. In terms of the population estimates given in Table 1, it will be noticed that the relative wide range of population sizes for the bluegills and crappies at the 0.95 limits of confidence is a direct consequence of the relatively small numbers of these species which were marked and recaptured. This could be remedied in future studies by marking the centrarchids more intensively and possibly for a longer period of time than would be necessary for the bullheads.

The first basic assumption requisite for the use of the mark and recapture method of population estimation is that the marked fish be randomly distributed and/or that the samples after the release of marked fish be taken at random. In the north section of the lake most of the fish, whether large or small, were taken in the shallower waters during the earlier part of April. Later, however, the larger fish (especially the bullheads) had a tendency to become scarcer in both the shallow and deep water sets. This would indicate that the larger fish died off at an abnormal rate and/or that they became inaccessible to the traps by extending their

distribution into more pelagic and deeper benthic areas where traps were not set. Studies now in progress indicate that these species do, in fact, become more widely distributed as the spring spawning season progresses. This type of bias in sampling became especially noticeable when the average size of the recaptured bullheads started to decrease after four or five weeks, necessitating the discontinuance of the census. Ricker (1942) pointed out the possibility of a similar bias for marked and tagged bluegills and red-ear sunfish.

A nonrandom sampling bias can also be introduced by the tendency of some marked fish, especially the bullheads, to become "trap susceptible." In such an instance, the marked fish would be recaptured with an abnormally high frequency (Lagler and Ricker, 1942; Schumacher and Eschmeyer, 1943). This tendency could possibly be circumvented by releasing all the marked fish in the center of the lake, so that they would become more or less randomly dispersed, although during spawning periods this procedure might well alter the normal activities of the fish. In this study, trap susceptibility was found to be eliminated by releasing the fish in the immediate area where they were captured, by removing the traps after no more than 24 hours in one location, and by allowing several days to elapse between successive samplings in any one place.

In the relatively isolated north and south sections of the lake, trapping and marking were carried out at intensities which were not known to be in proportion to the sizes of the populations present. This procedure would also result in a bias of random sampling if the samples from both parts of the lake were to be combined (Lagler and Ricker, 1942). For this reason it was necessary to compute the census estimates separately for each section of the lake.

The second basic assumption of the mark and recapture technique is that there be no difference between the marked and unmarked fish. There were no indications that there was excessive mortality among the marked fish. In fact, of all the bullheads which were found dead during the period of marking, not one had been marked. Data presented by Ricker (1949) would also indicate that bluegills of the sizes marked in this study should not experience greater mortality than those which were unmarked. Another difference between marked and unmarked fish is that the unmarked fish may be continuously growing into the size range being sampled. Fortunately during the month of April and part of May in Searsville Lake, the yearling fish, which were the smallest size sampled, tended to increase in size as the study continued. This would indicate that little recruitment, if any, was taking place at this time of year for the size ranges in question.

The upper and lower 0.95 limits of confidence in Table 1 are calculated on the basis of the Poisson approximation derived by Chapman (1948). Thus, the values of the population estimates would lie outside the calculated limits in only one chance in 20 if the basic assumptions of the mark and recapture technique were not violated. Since no *a priori* information existed on which an upper limit for each of the populations could be established, the question of how many fish should be marked and how many should be handled cannot be solved and consequently the range of the limits could not be predicted at the outset of the marking operations. It is evident that the ranges for the bluegills and crappie population estimates are perhaps too large for practical purposes. These limits

could be reduced only by insuring a greater proportion of recaptured fish in the samples by marking and releasing more fish or by continuing the procedure over a longer time. If the procedure were carried out over a longer period, natural mortality, recruitment, and the possibility of biased samples resulting from changes in behavior must be considered. As mentioned above, there was some evidence that the larger fish tended to become relatively less abundant in the traps after one month of operations. The resulting bias in the sampling of the total populations could be eliminated only by using different gear. Owing to the rapid growth and death of species in the relatively warm waters of Searsville Lake, corrections for mortality and recruitment would undoubtedly be large and could detract considerably from estimates of populations made over a period of time much longer than a month. Thus, it would seem that better population estimates for the bluegills and crappies could best be made by confining the operations to a period of about one month and by increasing the intensity of marking and sampling to insure a larger number of recaptures of these two species.

As carried out by one man, the operations involved the daily use of only 8 to 16 of the wire traps with not over 30 days of work at less than six hours per day. It is believed that at least 40 traps could be handled twice daily by one man if an increased intensity of sampling were desired.

The standing crops of the bullheads, bluegills, and black crappies expressed on a pounds-per-acre basis (Table 2) are quite large when compared to the populations of other bodies of water listed by Carlander (1950). Of those bodies of water listed by Carlander as having standing crops over 150 pounds per acre, most are small lakes of the Lake States or ponds of the Midwest and South. A perusal of the literature from which these values were taken indicates that the higher standing crops per acre are often for small, specially managed ponds, for ponds and lakes where fishes of all sizes were taken by poisoning or draining, or for lakes where large populations of coarse and forage species were present. Even if the population size of the largemouth bass for Searsville were not considered in addition to the species above, the reservoir would undoubtedly be among the best of those known in the United States for similar game fish.

The comparisons of the different populations of fish on a pounds-per-acre basis are admittedly arbitrary, even though the same species of fishes are present in the waters being compared. Comparisons of populations in waters whose basins are morphometrically dissimilar are especially hazardous, even though the surface areas of the different waters be equal. Further, in fluctuating reservoirs the morphometry changes with the water level and it would be difficult to compute an average area which could be expected to have any known degree of biological significance. In Searsville Lake, taken as a whole, the capacity and the area plotted against depth form two curves which are essentially identical when area and volume are plotted on the same axis in scales of the same length, i.e., the volume and the area of the lake decrease with a dropping water level at the same relative rates. A comparison of the deeper north section with the shallower south section during drawdown indicates that the area decreases much more rapidly in the southern section. Because the southern section is so shallow, its relative volume is much diminished, while the relative volume of the north section is but slightly diminished

for drawdowns of the normal magnitude. The dense growths of aquatic vegetation must also be considered in making an estimate of the volume or area of the lake sections. It was found that traps placed within the dense growths ordinarily did not catch fish even when the weeds were carefully separated at the mouth of the trap. The traps were successful, however, in catching fish in the open or partially open areas between patches of dense growth. Bennett (1948) notes that the yields of fish from a small pond tend to vary in a general way inversely with the abundance of plants and directly with the area of open water. In Searsville, the dense growths of plants are maintained in advance of the retreating shoreline during summer drawdown up to a depth of about 13 feet (4 meters). Thus, with the lake at spillway level for six to eight months of the year, only a part of the shallower waters is open enough to support fish. For the remaining four to six months when the lake is drawn down there is an additional loss of environmental space. On the whole, it was very crudely estimated that the average annual amount of open waters had an area equal to that within the two meter ($6\frac{1}{2}$ feet) contour.

If the relatively equal catches per unit of effort for the north and south sections of the lake are any indication of approximately equal densities of fish in these two parts of the lake, the expression of densities on a pounds-per-acre basis at the high water level in column 5 of Table 2 is rather unrealistically low for the southern section. Computation of densities on the basis of the approximate average amount of open waters in the last column of Table 2, on the other hand, seems to be much more reasonable. Much more data on the distribution and space requirements of fish at all times of the year will be necessary before the arbitrary expressions of densities per unit area of open water can be replaced by the more desirable expression of densities on a volume basis.

SUMMARY

The use of wire traps for sampling fish populations in order to make estimates of the total populations in a weedy reservoir is to be recommended in cases where the use of nets is difficult and where manpower is limited.

Population estimates by the mark and recapture technique for brown bullheads over six inches in total length, bluegills and black crappies over four inches in total length were made for two nearly isolated sections of Searsville Lake. For a deeper section of 34.9 acres at high water, the estimated numbers of these three species were, respectively, 10,554, 4,119, and 4,542; for a very weedy, shallow section of 39.9 acres at high water, the estimated numbers of these three species were, respectively, 5,693, 665, and 1,201. In order to insure random sampling of both the bullheads and the Centrarchids and in order to avoid biases due to possible changes of distribution of these species, it is suggested that the marking and recapturing procedure be carried on within a period of about one month for the spring spawning season.

It was found that an expression of the standing crops on a per-acre basis for this weed-choked reservoir were much more realistic when the acreages at the low water level were used. On the low water basis the total standing crops for the bullheads, the bluegills, and the crappies were approximately equal to 162 pounds per acre in each of the sections of

the lake, while on a high water basis the standing crop in the shallower portion was disproportionately low. The brown bullheads were the dominant species in both numbers and weight in both sections of the lake. Though the relative abundance of all three species was of the same general magnitude in each section, the exact proportions of the three species in the two sections were somewhat different. On the basis of known populations of game species in other lakes, ponds, and reservoirs in the United States, the populations in Searsville Lake are fairly large on an areal basis. The value of population studies on unfished waters of this reservoir is emphasized, because a knowledge of the numbers and proportions of different species which occur in a state of natural balance is indispensable for an understanding of the balance of populations in other bodies of water which are influenced by selective removal by fishermen.

REFERENCES

Bennett, George W.
1948. The bass-bluegill combination in a small artificial lake. Illinois Nat. Hist. Surv. Bull., vol. 24, art. 3, p. 377-412.

Calhoun, A. J.
1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish and Game, vol. 36, no. 3, p. 177-234.
1951. California state-wide angling catch estimates for 1949. Calif. Fish and Game, vol. 37, no. 1, p. 69-75.

Carlander, Kenneth D.
1950. Handbook of freshwater fishery biology. Wm. C. Brown Co., Dubuque, Iowa. 281 p.

Chapman, D. G.
1948. A mathematical study of confidence limits of salmon populations calculated from sample tag ratios. Internat. Pacific Salmon Fish. Comm., Bull. 2, no. 2, p. 69-85.

Felin, Frances
1940. The seasonal fluctuation of benthic macrofauna and limnetic plankton in Searsville Lake. A contribution to the biology of fluctuating reservoirs. Doctoral dissertation, Stanford University.

Grinnell, Joseph
1935. A revised life-zone map of California. Univ. Calif. Publ. Zoology, vol. 40, no. 7, p. 327-330.

Lagler, Karl F. and William E. Ricker
1942. Biological fisheries investigations of Foots Pond, Gibson County, Indiana. Invest. Indiana Lakes and Streams, vol. 2, no. 3, p. 47-72.

Ricker, William E.
1942. Creel census, population estimates and rate of exploitation of game fish in Shoe Lake, Indiana. Invest. Indiana Lakes and Streams, vol. 2, no. 12, p. 215-253.
1948. Methods of estimating vital statistics of fish populations. Indiana Univ. Publ., Science Ser., no. 15, 101 p.
1949. Effects of removal of fins upon the growth and survival of spiny-rayed fishes. Journ. Wildlife Management, vol. 13, no. 1, p. 29-40.

Schnabel, Zoe E.
1938. The estimation of the total fish population of a lake. American Math. Monthly, vol. 45, no. 6, p. 348-352.

Schumacher, F. X., and R. W. Eschmeyer
1943. The estimate of fish population in lakes or ponds. Tennessee Acad. Sci. Journ., vol. 18, no. 3, p. 228-249.

Scott, Flora M.
1927. Introduction to the limnology of Searsville Lake. Stanford Univ. Publ., Biol. Sci., vol. 5, No. 1, p. 1-83.

WEEKDAY ANGLING PRESSURE IN THE SACRAMENTO-SAN JOAQUIN DELTA, 1948 AND 1949[1]

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INTRODUCTION

The Sacramento-San Joaquin Delta in California is one of the most popular and productive large sportfishing areas in the State. The delta is an intricate network of waterways separated by low islands that are protected by levees, and its waters aggregate about 500 miles of channels of various sizes. The widest channel is more than 4,000 feet wide, but some of the waterways measure less than 100 feet from bank to bank. Situated only an hour's drive from the large urban areas of the San Francisco Bay region, well supplied with highways and access roads, and with many bait shops, boat liveries, and other facilities for the angler, the delta area has developed into a sport fishermen's recreation ground that is probably unequaled in popularity by any other area of its size in California.

Sport fishing in the delta area is directed toward several kinds of prized game fishes, some of which also enter the commercial fishery in the same waters. Foremost among the fishes sought by sport anglers in the delta is the striped bass (*Roccus saxatilis*), whose adults utilize these waters for feeding and spawning, and whose immature stages undergo much of their development here. The white catfish (*Ictalurus catus*) is greatly sought in delta waters, and is abundant throughout much of the maze of channels making up the area. The brown bullhead (*Ameiurus nebulosus*) often appears in delta catches, and, on rare occasions, the channel catfish (*Ictalurus lacustris*) is taken. A small sport fishery for king salmon (*Oncorhynchus tshawytscha*) is found on the outskirts of the delta (Sacramento and San Joaquin Rivers), although this fishery is of minor importance compared to the salmon fisheries occurring above the delta. Largemouth black bass (*Micropterus salmoides*), bluegill (*Lepomis macrochirus*), green sunfish (*Lepomis cyanellus*), and black crappie (*Pomoxis nigromaculatus*) are numerous in parts of the delta region, and many anglers seek them in their fishing efforts. With such a variety of resident and anadromous fishes available in the same waters, it is understandable that the Sacramento-San Joaquin delta should be so popular among sport fishermen in Central California.

The present paper deals with the amount of fishing effort observed over an extended period in various channels of the delta. Calhoun (1949) made a thorough treatment of the party boat fishery for striped bass in the delta from 1938 to 1948. His summary of boat days, angler days, and

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numbers of striped bass landed showed the enormous amount of effort expended and the large numbers of striped bass taken from party boats alone. Calhoun (1950), in his discussion of angling catches throughout the State, provided substantial evidence of the popularity of the delta area and of the success of anglers in delta waters, particularly with reference to striped bass and catfish. Calhoun (1951) compared angling catches for California in 1948 and 1949 for several species of fish, including those species that are most popular in the delta. Although total catch estimates, mean catch estimates, and numbers of successful anglers were slightly greater in 1949 than in 1948, the differences with respect to striped bass were not statistically significant. Differences in mean catches of catfish and black bass were statistically different, indicating decreases in success from 1948 to 1949. The present paper does not deal with catches nor with species, but provides some comparative figures on fishing effort from place to place in delta waters. A comparison is made also of fishing effort in the delta in 1948 and 1949. Trends in effort from month to month, and from weekday to weekday, are described.

The U. S. Fish and Wildlife Service was engaged in a biological survey of delta waters during 1948 and 1949. In the course of these investigations, routine collections of physical and biological data were made by

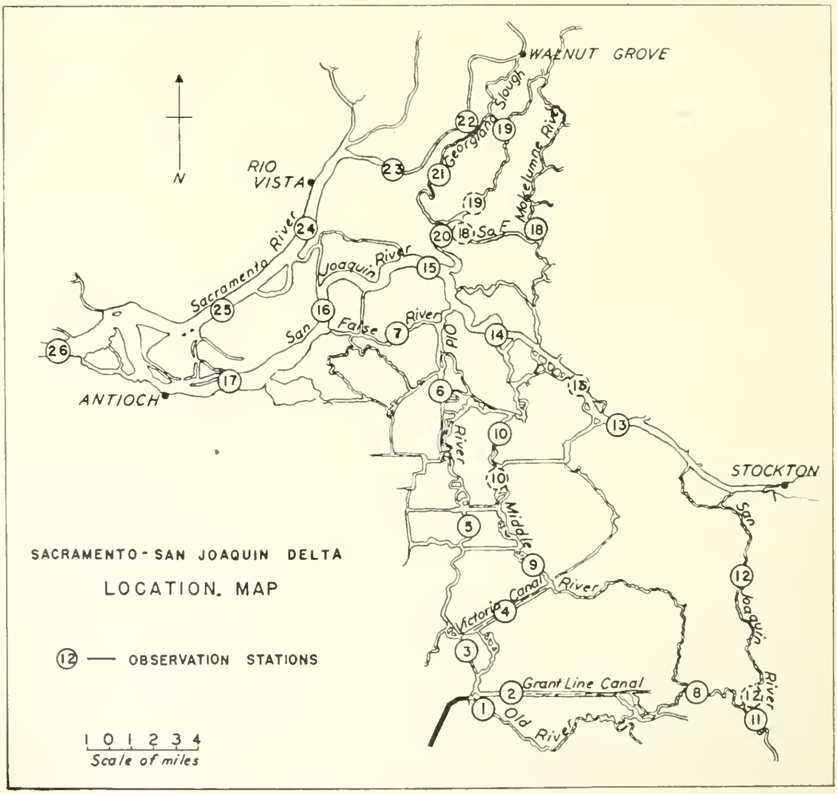

FIGURE 1. Locations of observation stations in the Sacramento-San Joaquin Delta. 1948 and 1949 stations are shown by number in solid circles. Stations relocated in 1949 are shown in broken circles.

boat at sampling stations distributed throughout most of the delta area, from Sacramento River below Walnut Grove on the north, to San Joaquin River below Mossdale on the south, and to the mouths of Sacramento and San Joaquin Rivers on the west. Twenty-five such stations were maintained in 1948.

In 1949, 20 of the 25 1948 stations were continued, and an additional site, Station No. 26, was added in the month of May. New locations were set up on the same streams to replace the five 1948 stations that were discontinued. The following list indicates the locations of the collecting stations visited (see also Figure 1) and their number designations.

Station No.	*Location*
1	Old River, Livermore Yacht Club upstream two miles.
2	Grant Line Canal, Grant Line Bridge to Old River.
3	Coney Island Cut, entire length.
4	Victoria Canal, entire length.
5	Old River, Woodward Canal to Santa Fe Railroad Bridge.
6	Holland Cut, entire length.
7	False River, overhead cables to Fishermen's Cut.
8	Middle River, San Joaquin River to Salmon Slough.
9	Middle River, Borden Highway Bridge to North Victoria Canal.
10 (1948)	Middle River, Santa Fe Railroad Bridge to Empire Cut.
10 (1949)	Middle River, Empire Cut to Connection Slough.
11	San Joaquin River, ½ mile below Southern Pacific Railroad Bridge, Mossdale, to Middle River.
12 (1948)	San Joaquin River, ½ mile below bifurcation of Middle River for two miles downstream.
12 (1949)	San Joaquin River, Brandt Bridge to Borden Highway Bridge.
13 (1948)	San Joaquin River, Navigation Light No. 21 to Light No. 17.
13 (1949)	San Joaquin River, Turner Cut upstream to Navigation Light No. 35.
14	Venice and Mandeville Cuts, Navigation Light No. 5 to Light No. 2.
15	San Joaquin River, Mouth of Mokelumne River to Seven Mile Slough.
16	San Joaquin River, Three Mile Slough to False River.
17	San Joaquin River, Blind Point to Mayberry Cut.
18 (1948)	South Fork Mokelumne River, North Fork to Terminous.
18 (1949)	South Fork Mokelumne River, Terminous to Sycamore Slough.
19 (1948)	North Fork Mokelumne River, mouth of South Fork upstream two miles.
19 (1949)	North Fork Mokelumne River, five miles above South Fork upstream two miles.
20	Mokelumne River, Georgiana Slough to Jackson's Harbor.
21	Georgiana Slough, Tyler Island Bridge to mouth of Slough.
22	Sacramento River, Pratt-Low Preserving Company Cannery to Isleton Highway Bridge.
23	Sacramento River, Isleton to Grand Island Sounding Board.
24	Sacramento River, west side of river, Rio Vista to Three Mile Slough.
25	Sacramento River, east side of river, Toland's Landing to Towers.
26 (1949)	Sacramento River, Bell-buoy No. 10 to Stake Point.

In 1948, each station was worked about once each week, on a weekday, from April 9 to December 15. Under this regime, almost all stations were visited 18 or 19 times during the year. In 1949, each station was worked once a week, Tuesday through Friday, from January 26 to September 21. This schedule covered each station, except No. 26, 32 or 33 times during the sampling season. Station 26 was visited 19 times in 1949. Although a truly random sampling schedule, with regard to day of the week and hour of the day for each station, was not followed, no station was visited always on the same day of the week or at the same hour of the day.

Observations on the numbers of anglers were made each time the boat operated at a station. While the operation, consisting of a half-hour net-tow, was in progress, personnel equipped with field glasses kept records

of the numbers of shore anglers and those in boats within the confines of the station. The lengths of stations varied from about one-half mile to two miles. The time for counting anglers on each station consisted of the half-hour duration of the tow plus a few minutes (up to 10 minutes) at the station before and after the actual towing.

ANGLING PATTERNS

In this report, angling has been divided into "shore fishing" and "boat fishing." Shore anglers fished from the banks or from piers with casting equipment or drop lines. Boat fishermen used skiffs (usually with outboard motors), small inboard launches, larger party boats, and a few large pleasure cruisers up to 50 or 60 feet long. Boat fishermen used a greater variety of angling equipment than did shore fishermen. Some trolled with lures; others anchored and fished with baited casting gear. Bait fishing for striped bass with chunks and filets of sardine was the most widely observed method seen in this study. Juvenile striped bass and catfish are the principal fish sought during the summer months, and large striped bass are the chief sport fish in the delta from mid-September through May.

No breakdown of boat effort into launch and skiff fishing was made in 1948. Although such a breakdown was made in the field in 1949, the detailed information shown here in tabular and graphic form compares boat fishing in general with shore fishing. Some figures are presented for the 1949 season as a whole, showing relative numbers of launches and skiffs used in the observation areas.

POPULAR AREAS

The 1948 and 1949 observations provide some interesting information on the relative popularity of different fishing areas (Tables 1 and 2). The tables, which summarize all observations over the 18-month period of study, cover totals of 3,253 anglers in 1948, and 7,246 in 1949, and embrace the results of 445 surveys in 1948, and 841 in 1949.

The best measure of the popularity of angling localities in the delta is provided by the average number of anglers seen per station per survey. The constancy of the popularity of certain places is also seen by comparing figures for the two years. Station 23 (Sacramento River, from Isleton to the Grand Island Sounding Board), for instance, was the most popular angling site in both years (27.72 anglers per observation in 1948, and 21.21 anglers in 1949). The ranking of the other stations was not the same in both years, but 11 of the 12 most popular fishing sites in 1948 were also among the first 12 in 1949. At these popular sites (with a few exceptions such as Stations 23 and 15), the 1949 counts of anglers were slightly higher than those for 1948. The average for all stations show 7.31 anglers per station in 1948 and 8.60 for 1949. Reference to Figure 2 will reveal, however, that the figures are not comparable, since the same period of months was not covered in the sampling periods for each year; October and November, months of heavy fishing in 1948, for example, were not covered in 1949. When the computation of the average is based only on the data for those months that were sampled in both years, *i.e.*, April through September, the figures become 6.23 anglers per station per survey for 1948 and 9.47 for 1949.

TABLE I

Summary of Data on Angling in the Delta in 1948

Station no.	Number of surveys	Total numbers observed				Average number per survey			
		Boats	Boat anglers	Shore anglers	Total anglers	Boats	Boat anglers	Shore anglers	Total anglers
1	18	3	5	25	30	0.17	0.28	1.39	1.67
2	18	14	31	25	56	0.78	1.72	1.39	3.11
3	19	4	8	75	83	0.21	0.42	3.95	4.37
4	19	1	2	2	4	0.05	0.11	0.11	0.21
5	19	57	138	21	159	3.00	7.26	1.11	8.37
6	18	13	32	7	39	0.72	1.78	0.39	2.17
7	19	34	91	6	97	1.79	4.79	5.32	5.11
8	14	3	8	16	24	0.21	0.57	1.14	1.71
9	19	22	49	43	92	1.16	2.58	2.26	4.84
10	19	44	99	31	130	2.32	5.21	1.63	6.84
11	14	3	6	50	56	0.21	0.43	3.57	4.00
12	10	3	7	3	10	0.30	0.70	0.30	1.00
13	19	17	38	1	39	0.89	2.00	0.05	2.05
14	19	42	99	2	101	2.21	5.21	0.11	5.32
15	19	140	322	4	326	7.37	16.95	0.21	17.16
16	19	40	86	42	128	2.11	4.53	2.21	6.74
17	19	63	124	95	219	3.32	6.53	5.00	11.53
18	18	31	76	48	124	1.72	4.22	2.67	6.89
19	18	26	60	40	100	1.44	3.33	2.22	5.55
20	18	113	258	81	339	6.28	14.33	4.50	18.83
21	18	9	21	118	139	0.50	1.17	6.56	7.72
22	18	12	24	63	87	0.67	1.33	3.50	4.83
23	18	110	244	255	499	6.11	13.56	14.17	27.72
24	18	32	72	128	200	1.78	4.00	7.11	11.11
25	18	35	88	84	172	1.94	4.89	4.67	9.56
Totals	445	871	1,988	1,265	3,253				

The most popular fishing sites at the time of the study were: Sacramento River, from Isleton to the mouth of the river; San Joaquin River from the mouth of Mokelumne River to Seven Mile Slough, from Three Mile Slough to False River, and from Blind Point to Mayberry Cut; Venice and Mandeville Cuts; South Fork of Mokelumne River in the vicinity of Terminous; Mokelumne River from Georgiana Slough to Jackson's Harbor; and Georgiana Slough from Tyler Island Bridge to the mouth of the slough. The amount of angling consistently noted in these areas was impressive. As noted above, Station 23 on Sacramento River averaged 27.72 anglers per survey in a series of 18 counts in the 1948 season. The same area, in 33 surveys in 1949, had an average of 21.21 anglers. At times, as many as 82 fishermen were seen in a single observation. Station 15 on San Joaquin River averaged 17.16 anglers per survey in 1948, and 15.24 in 1949 (109 were seen on one occasion). Station 14, on Venice and Mandeville Cuts, with 104 anglers, Station 12, on San Joaquin River, with 99 anglers, Station 3 on Coney Island Cut, with 99 anglers, Station 25, on Sacramento River, with 90 anglers, and Station 4, on Victoria Canal, with 83 anglers, are additional examples of notable concentrations of sport fishermen on single occasions.

Although both boat and shore fishermen contributed to the remarkably high counts, it is of interest to note the proximity of the most popular fishing sites to liveries where launches and skiffs are available to fishermen. Station 15 on San Joaquin River is just around a bend of the river

TABLE 2

Summary of Data on Angling in the Delta in 1949

Station no.	Number of surveys	Total numbers observed				Average number per survey			
		Boats	Boat anglers	Shore anglers	Total anglers	Boats	Boat anglers	Shore anglers	Total anglers
1	33	14	30	54	84	0.42	0.91	1.64	2.55
2	33	20	48	138	186	0.61	1.45	4.20	5.65
3	33	20	43	72	115	0.61	1.30	2.18	3.48
4	33	4	8	13	21	0.12	0.24	0.39	0.63
5	33	64	141	58	199	1.94	4.27	1.76	6.03
6	33	59	129	5	134	1.78	3.91	0.15	4.06
7	33	70	175	9	184	2.12	5.30	0.27	5.57
8	32	8	18	90	108	0.25	0.56	2.81	3.37
9	33	40	87	83	170	1.21	2.64	2.51	5.15
10	33	52	125	131	256	1.57	3.78	3.97	7.75
11	32	11	26	130	156	0.34	0.81	4.06	4.87
12	32	8	19	131	150	0.25	0.59	4.09	4.68
13	33	16	32	181	213	0.48	0.97	5.48	6.45
14	33	179	413	41	454	5.42	12.51	1.24	13.75
15	33	217	487	14	503	6.57	14.82	0.42	15.24
16	33	79	184	137	321	2.39	5.57	4.15	9.72
17	33	111	278	188	466	3.36	8.42	5.70	14.12
18	33	59	140	261	401	1.79	4.24	7.91	12.15
19	33	35	79	191	270	1.06	2.39	5.79	8.18
20	33	156	337	113	450	4.72	10.21	3.42	13.63
21	33	19	39	425	464	0.57	1.18	12.88	14.06
22	33	33	78	183	261	1.00	2.36	5.54	7.90
23	33	161	351	349	700	4.88	10.64	10.57	21.21
24	33	52	104	237	341	1.57	3.15	7.18	10.33
25	33	70	155	394	549	2.12	4.70	11.93	16.63
26	19	4	7	83	90	0.21	0.37	4.36	4.73
Totals	841	1,561	3,533	3,711	7,246				

from six boat liveries, and Station 20 on Mokelumne River lies in the midst of this same group of six boat-rental establishments. Station 7 on False River is situated near the popular Frank's Tract, with its cluster of six liveries. Station 14 on San Joaquin River has one boat livery close at hand, and Station 23 on Sacramento River near Isleton is served by three rental docks. Station 17 on San Joaquin River has the benefit of six boat liveries, all located on the south shore in the vicinity of Antioch. Reference to Tables 1 and 2 will disclose that these particular stations rank high in point of number of boat anglers observed. Some of them, such as Stations 17 and 23, are also frequented by numbers of shore anglers.

Those stations supporting the greatest numbers of shore fishermen in both years were Station 21 on Georgiana Slough, Stations 23 and 24 on Sacramento River, and Station 17 on San Joaquin River. Station 25 on Sacramento River was popular for shore fishermen in 1949, but held a mediocre rank in 1948. Station 18, as relocated in 1949, on the South Fork of Mokelumne River apparently also increased in popularity from 1948 to 1949, for the months surveyed. Much of this increase can be attributed to the relocation, with more shore anglers in evidence. These stations, which proved to be the most popular, are all easily accessible by automobile. This fact undoubtedly contributed materially to their heavy use by shore anglers, although many other areas that can be easily reached by road did not approach these in popularity.

TABLE 3

Average Number of Anglers Observed Per Station Per Survey, by Months, 1948 and 1949

Month	1948			1949		
	Boat anglers	Shore anglers	Total anglers	Boat anglers	Shore anglers	Total anglers
January	----------	----------	----------	2.04	1.68	3.72
February	----------	----------	----------	6.64	2.68	9.32
March	----------	----------	----------	1.58	3.05	4.63
April	6.39	2.90	9.29	7.96	6.99	14.95
May	4.51	2.59	7.10	5.98	4.32	10.30
June	2.67	2.38	5.05	2.48	4.00	6.48
July	2.18	3.25	5.43	2.93	6.36	9.29
August	1.93	2.92	4.85	2.89	4.58	7.47
September	2.65	3.74	6.39	4.82	5.64	10.46
October	14.04	4.87	2.71	----------	----------	----------
November	20.02	2.71	22.90	----------	----------	----------
December	3.81	0.91	4.72	----------	----------	----------

It should be emphasized that our sampling locations were determined by the requirements of our general program and hence many of the most popular fishing areas in the delta were not covered in the present survey. Frank's Tract, for instance, was not included in our observations. Although Station 7 on False River lies on the northern boundary of Frank's Tract, only the anglers within the station itself, on False River, could be counted successfully. Among other popular areas not touched in these surveys were Sherman Island Lake and Big Break on Dutch Slough.

MONTHLY TRENDS

The data on monthly fluctuations of angling pressure have been arranged to permit the comparison of trends in 1948 and 1949 (Table 3 and Figure 2). The trend during the months in which counts were made in both 1948 and 1949, April through September, agree rather faithfully. The 1949 values were higher than those for 1948, and the increases and decreases for the two years were not always proportional, but the trends were in the same directions for the six months involved. For example, numbers of anglers per station per survey were lower in May than in April in both 1948 and 1949. Furthermore, in both years June was lower than May, July was higher than June, August was lower than July, and September was higher than August. When the figures on shore anglers are considered in relation to those of the boat anglers, it is seen that the principal part of the fluctuations in 1948 were due to boat anglers; counts of shore anglers were far more stable than those for boat anglers. This relationship, in general, held for 1949 also, but it was not as clear-cut as in 1948.

The most striking feature of these figures is the high value of the October and November averages in 1948. The advent of fishing for large striped bass, which begins in September or October and continues through the winter and into the spring, coincides with these high values. The beginning of the upward trend is seen in the average for September, 1948, when an increase over summer month counts occurred. The same trend appeared in September, 1949.

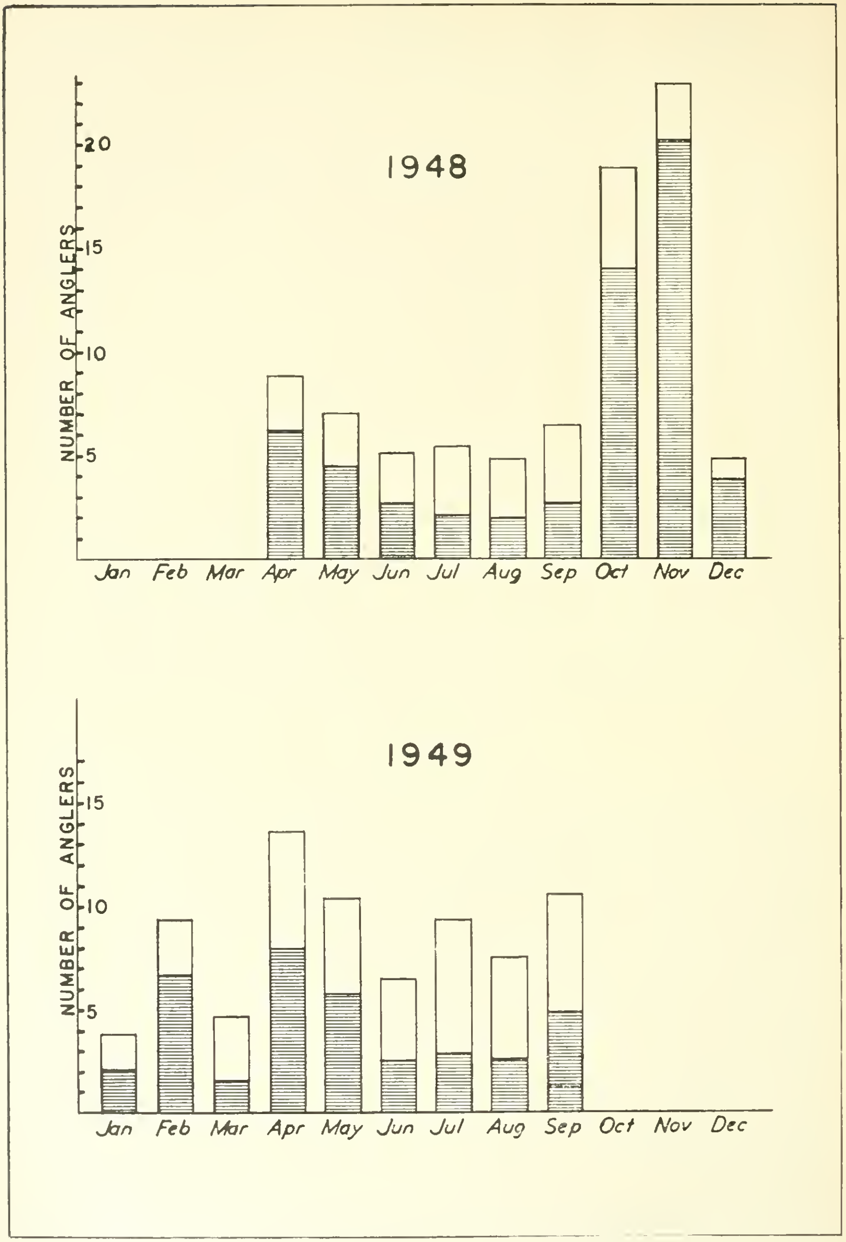

FIGURE 2. Average number of anglers per station by month, all stations, 1948 and 1949. Shaded areas denote boat anglers, clear areas denote shore anglers.

TABLE 4

Total Numbers of Anglers and Numbers of Anglers Per Station Per Survey, According to Days of the Week

Item	Monday		Tuesday		Wednesday		Thursday		Friday	
	1948	1949	1948	1949	1948	1949	1948	1949	1948	1949
Number of boat anglers	178	No observations made	504	1,758	338	1,148	488	628	469	279
Number of shore anglers	224		301	695	243	1,382	246	1,368	236	426
Total number of anglers	402		805	2,453	581	2,530	734	1,996	705	705
Boat anglers per survey	2.66		4.75	7.10	3.10	3.59	5.81	2.51	6.01	4.44
Shore anglers per survey	3.34		2.84	2.76	2.23	4.33	2.93	5.49	3.03	6.74
Total anglers per survey	6.00		7.59	9.86	5.33	7.92	8.74	8.00	9.04	11.18

The low counts of December, 1948, are explainable on the basis of poor weather. Subnormal temperatures prevailed in the delta area throughout the month, and unusual ice formation in quiet waters in the delta was noted on several occasions.

TRENDS WITHIN THE WEEK

The study of trends in fishing pressure within the week is handicapped by a paucity of counts on Saturdays and Sundays. Comparisons between 1948 and 1949 are limited further by the lack of counts on Monday in the latter year. Presentation of data in this section, therefore, is limited to Monday through Friday in 1948 and Tuesday through Friday in 1949 (Table 4 and Figure 3). The data on weekday fluctuations are based on counts made in all months of observation.

Even with the limitations just outlined, however, some interesting relationships can be recognized. The 1949 figures for number of anglers per station per survey are obviously somewhat higher than those for 1948. Further, the greater variability in the numbers of boat anglers as compared with the numbers of shore anglers described earlier in the section on monthly trends is to be found also in the figures on daily trends. For the four weekdays for which there are data in both years, Friday had the highest and Wednesday the lowest average counts. Tuesday and Thursday did not hold the same rank in both years, but each was either second or third in importance in both 1948 and 1949.

RATIO OF SKIFFS TO LAUNCHES

It was mentioned earlier that in 1948 no breakdown was made of boat anglers into those in launches and skiffs. Some figures on this point are available for 1949. The 1949 counts were not treated by month or by day of the week, but are presented here for the season as a whole. In the 1949 surveys, 1,534 boats were counted. Of this number, 1,273 were skiffs, either with or without outboard motors, and the remaining 261 were inboard-powered launches of various sizes. The ratio of skiffs to launches for 1949, therefore, was approximately 5:1. The total number of boats counted in the 1948 surveys was 870; if the same 5:1 ratio applied in that year, there would have been about 725 skiffs and 145 launches.

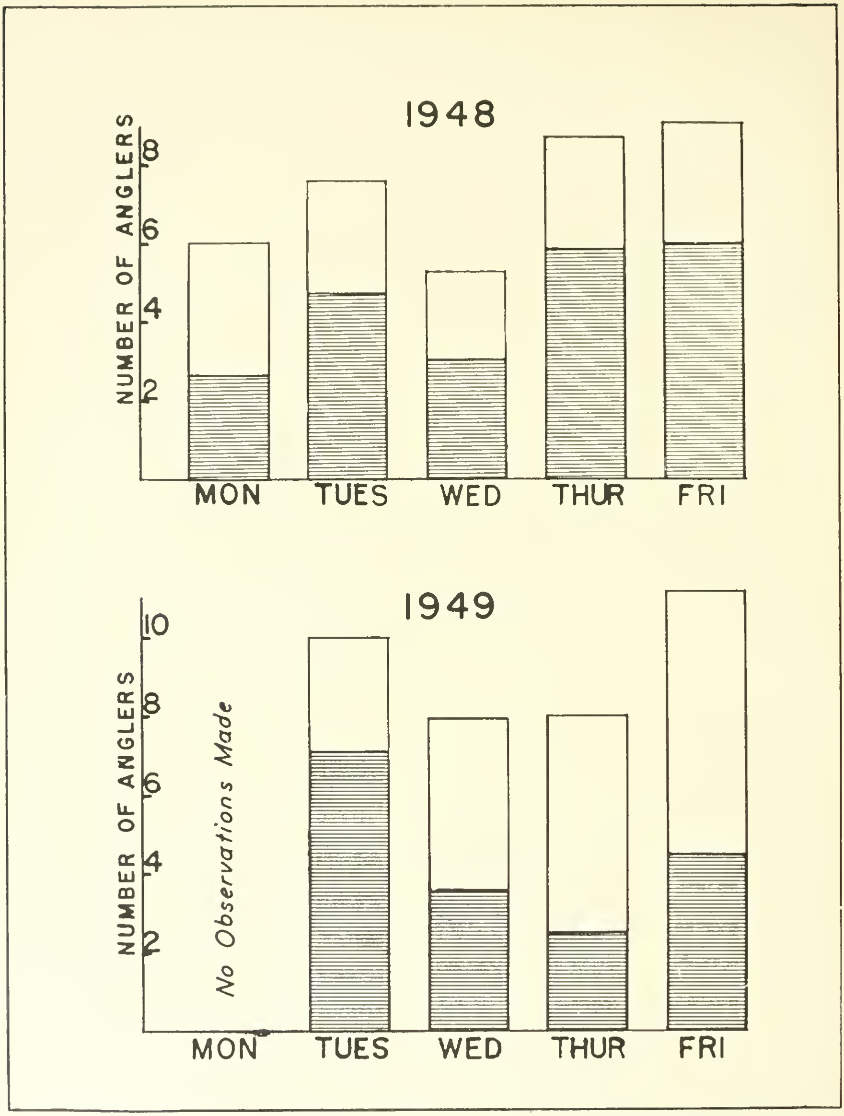

FIGURE 3. Average number of anglers per station by weekday, all stations, 1948 and 1949. Shaded areas denote boat anglers, clear areas denote shore anglers.

TOTAL ANGLING EFFORT

It would be highly desirable to know the total number of anglers using delta waters in a year's time. The present data do not permit treatment for an accurate determination of such a total, since certain accessory information is lacking. In the absence of reliable figures concerning the hourly turnover of anglers in the delta, any attempt to project the present data into an annual total would be little more than a rough estimate. On the other hand, even an approximate value will indicate the order of magnitude, and will be of interest to all who fish in the delta.

If we assume that the average delta angler fishes for a half-day, and that in 1948 the average number of anglers per station per survey was approximately seven, and that the corresponding number for 1949 was 10, the following estimates of annual values are obtained: 1948, 91,000; 1949, 130,000. It should be emphasized that these figures represent only the number of weekday anglers using the localities here discussed. Saturdays and Sundays, which would probably each support more anglers than a week's days combined, are not included. Another point not considered here is the great number of delta localities lying outside the area of this study. These localities include not only those places between sampling stations on the various channels, but several particularly active sites, such as Frank's Tract, Sherman Island Lake, and Big Break on Dutch Slough. No attempt is made here to extend the present estimate to include weekends or other areas.

SUMMARY

During the course of biological investigations in the Sacramento-San Joaquin Delta in 1948 and 1949, Fish and Wildlife Service personnel made routine surveys of the numbers of sport anglers present at collecting stations while net tows were being made. Twenty-five stations were visited at intervals from April, 1948, through April, 1949, and 26 from May, 1949, through September, 1949.

The monthly averages of the numbers of anglers observed per station per survey indicate that for those months in which observations were made in both 1948 and 1949 (April through September), the trends from month to month followed each other closely in the two years. The actual counts in 1949, however, were higher than those in 1948. Fishing pressure in October and November, 1948 (no counts were made in those months in 1949), was heavier than in other months of the year. The fluctuations from month to month can be attributed largely to changes in boat angling pressure, since the numbers of shore anglers remained nearly constant from month to month.

Average counts on different days of the week revealed angling pressure to be highest on Fridays and lowest on Wednesdays in both 1948 and 1949. (No data were collected for Saturday or Sunday in either year or for Monday in 1949).

Average counts for the different localities proved that the most popular areas in 1948 were popular in 1949, as well.

It is estimated roughly that 91,000 anglers fished observed waters in 1948, and 130,000 anglers used them in 1949. This estimate does not include Saturdays or Sundays, or areas not included in the survey.

REFERENCES

Calhoun, A. J.
1949. California striped bass catch records from the party boat fishery: 1938-1948. Calif. Fish and Game, vol. 35, no. 4, p. 211-253.

1950. California angling catch records from postal card surveys: 1936-1948; with an evaluation of postal card nonresponse. Calif. Fish and Game, vol. 36, no. 3, p. 177-234.

1951. California state-wide angling catch estimates for 1949. Calif. Fish and Game, vol. 37, no. 1, p. 69-75.

AVERAGE LUNAR MONTH CATCH BY CALIFORNIA SARDINE FISHERMEN, 1949-50 AND 1950-51[1]

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INTRODUCTION

The Pacific sardine (*Sardinops caerulea*), fished from British Columbia to Mexico, has been under investigation for 30 years, and several reports on the measures of the success of the fishermen have been published. The most recent (Clark and Daugherty, 1950) reviewed previous work and summarized the average lunar month catch of the California fishermen for the seasons 1932-33 through 1948-49. This report is a continuation of those calculations for the following two seasons and is here presented to make current records available to other individuals and agencies studying the sardine.

Except as noted, the methods used are the same as those described in the 1950 report. Tables 1 and 4 of the former report have not been repeated but extensions for the 1949-50 and 1950-51 seasons are here shown in Tables 1 and 2. In this report no data are given for the San Francisco fishery alone. During the past two seasons not enough sardines were taken off San Francisco to permit any calculations of fishing success at this port and there is nothing to add to previously published records. The few deliveries made at San Francisco are included, however, in the calculations for the entire California fishery.

TABLE 1

Dates of Lunar Months Used for Comparison of the Catch of Each Boat With Its Catch in the Corresponding Lunar Month of the Previous Season

Lunar month	Season		
	1948-49	1949-50	1950-51
"August"	July 22–Aug. 19	Aug. 9–Sept. 7	July 30–Aug. 27
"September"	Aug. 20–Sept. 17	Sept. 8–Oct. 6	Aug. 28–Sept. 26
"October"	Sept. 18–Oct. 16	Oct. 7–Nov. 5	Sept. 27–Oct. 25
"November"	Oct. 17–Nov. 15	Nov. 6–Dec. 4	Oct. 26–Nov. 24
"December"	Nov. 16–Dec. 14	Dec. 5–Jan. 2	Nov. 25–Dec. 23
"January"	Dec. 15–Jan. 13	Jan. 3–Feb. 1	Dec. 24–Jan. 22
"February"	Jan. 14–Feb. 12	Feb. 2–Mar. 3	Jan. 23–Feb. 20

[1] Submitted for publication July, 1951.

TABLE 2

Number of Boats Used in the Calculation of the Average Lunar Month Catch Compared With the Total Number of Boats Fishing

Seasons compared	Number of boats					Tons, all California		
	Used in the analysis			Total fishing		Used in analysis	Total	Percent of total
	Monterey	San Pedro	All California	All California	Percent of total			
1948-49	79	171	280*	372	75	114,366	159,117	72
1949-50						249,783	334,115	75
1949-50	96	183	287*	349	82	283,576	334,115	85
1950-51						238,462	350,548	68

* Does not equal sum of two ports since certain boats could be used for one comparison but not for another.

SELECTION OF A BASE YEAR

Because of the constantly changing character of the fishing fleet, with very few boats remaining in the fishery for many seasons, it has always been necessary to express each fishing boat's catch as a ratio of its own catch in the corresponding lunar months of the two adjacent seasons and to link these ratios to a base year. In all previous studies the base year has been 1932-33. These measures of average lunar month catch now extend over 19 seasons and it is desirable to select a new base year and thus develop an average monthly catch which more nearly expresses the attainments of the present sardine fleet.

Silliman and Clark (1945, p. 35-38) showed that by 1941-42 the average sizes of the boats fishing out of San Francisco, Monterey, and San Pedro were approximately equal. There has been no great increase in average vessel size in the more recent years and consequently 1941-42 has been selected as the new base year. With this new base it was necessary to relink the average lunar month catches of the fishermen for the entire California fishery and for the Monterey and San Pedro fisheries. These new calculations are given in Tables 3-8 both in terms of tons and of numbers caught.

SELECTION OF BOATS

The basic rule for selection of vessels whose catches will be used in each season's analysis is that deliveries of a boat will be included if that boat fished in two successive seasons and made deliveries in at least two of the four weeks in the lunar month. In the past two seasons, due to unfavorable economic conditions and poor fishing, some departures from this basic rule were necessary. In the 1949-50 season, strikes and partial cannery closures made necessary some rough assumptions involving boat activities, which do not follow any particular rules. In 1950-51, fishing was very poor at San Francisco and Monterey, particularly after the first month; therefore, boats delivering at those ports that made only single landings (or zero landings in September, provided they made deliveries at any ports the preceding and following lunar months) were

considered as fishing full months. At San Pedro the previously used criteria were applied in October-December. In January and February, however, fishing became rather poor. In January boats making at least two deliveries, even though in the same lunar week, were assumed to be fishing all month providing they made deliveries in February. In a few cases, in January and February, boats known to be fishing, although unsuccessful, were assigned zero catches.

CORRECTION FOR LIMITS

During the 1949-50 season, as in 1948-49, economic conditions were unfavorable and there was a limited demand for canned sardines or sardine meal and oil. Because of this, throughout the season varying limits were placed on the number of tons that the fishermen could deliver on specific days. Comparison of the sizes of the catches when no limits were in effect with those held down by limits indicated that correction factors would be needed. At San Francisco no adjustments were necessary for any catches except those made in August and September. For these the weighting factor was 1.507. At Monterey catches made in August and September were materially smaller than they would have been without limits and these were weighted by a factor of 1.932. In October a factor of 1.136 was used. No corrections were necessary for the remainder of the season. At San Pedro limits held the catches down throughout the entire season and a weighting factor of 1.151 was used for all months.

In 1950-51 sardines were less abundant on the fishing grounds and economic conditions were better. As a result, limits were placed on the daily catches for a short time only. No corrections were applied to the few San Francisco deliveries; at Monterey catches made in August were weighted by a factor of 1.02215 and at San Pedro the catches made in October were multiplied by 1.0575.

FISHING SUCCESS IN 1949-50 AND 1950-51

The improvement in fishing success which began in 1948-49 was continued in 1949-50 as is shown in Figures 1 and 2 and Tables 3-8. Unfortunately this upward trend did not continue in 1950-51 and the average lunar month catch in the entire California fishery declined to 65 percent of 1949-50. The lack of sardines on the Central California fishing grounds resulted in a near failure at Monterey and a complete collapse at San Francisco. The Monterey average catch in tons was only 20 percent of the previous season. In Southern California sardines were found in fair abundance throughout the season. The average tonnage caught per month for this area, although only 75 percent of 1949-50, was still above that of the three previous seasons, 1946-47 through 1948-49. For these recent seasons the trends, based on numbers of fish per lunar month, differ but little from those based on tonnage.

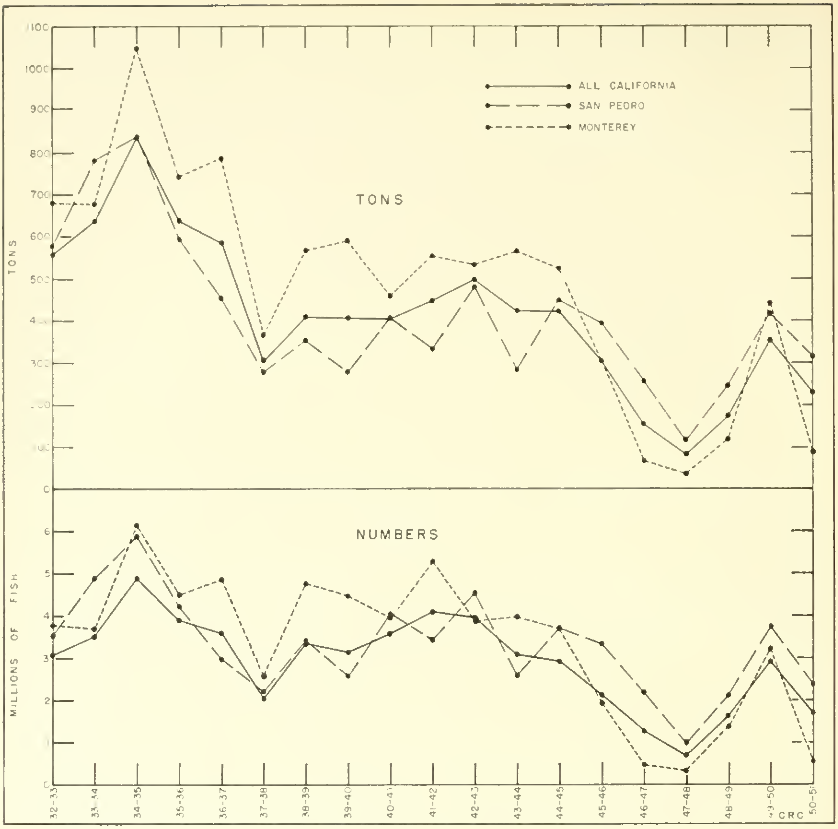

FIGURE 1. Average lunar month catch in tons and in numbers of sardines, base year 1941-42

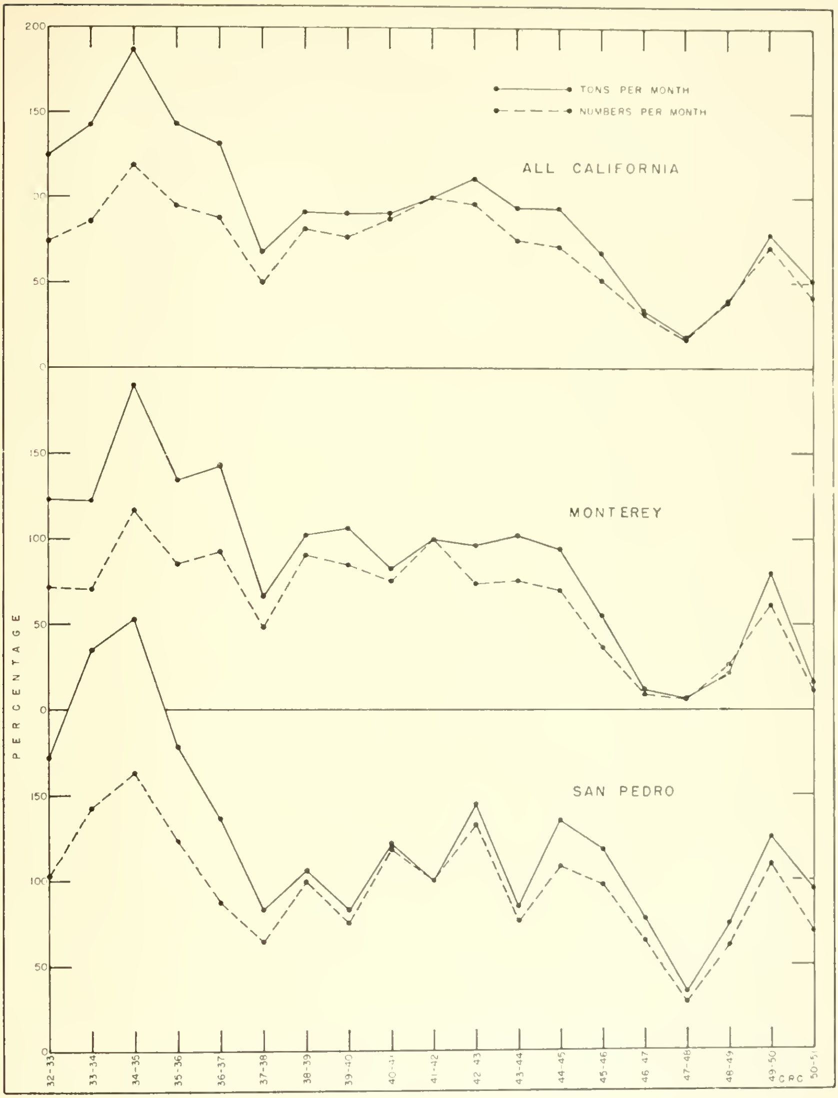

FIGURE 2. Average lunar month catch of sardines in percentage of 1941-42

TABLE 3

Average Lunar Month Catch for All California (in Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch, tons	Total boat months
	Tons	Ratio	Tons	Percent		
1932-33	426.0	.8755	557.3	124.75	248,956	446.7
1933-34	486.6					
1933-34	459.5	.7624	636.5	142.49	381,662	599.6
1934-35	602.7					
1934-35	600.2	1.3082	834.9	186.90	597,226	715.3
1935-36	458.8					
1935-36	509.4	1.0899	638.2	142.87	557,996	874.3
1936-37	467.4					
1936-37	495.3	1.9378	585.6	131.09	723,731	1,235.9
1937-38	255.6					
1937-38	279.0	.7397	302.2	67.65	413,384	1,367.9
1938-39	377.2					
1938-39	387.0	1.0081	408.6	91.45	572,466	1,401.0
1939-40	383.9					
1939-40	404.7	1.0027	405.3	90.72	531,878	1,312.3
1940-41	403.6					
1940-41	466.5	.9048	404.2	90.48	454,709	1,125.0
1941-42	515.6					
1941-42	446.7		446.7	100.0	583,463	1,306.2
1942-43	497.4	1.1135	497.4	111.35	501,341	1,007.9
1942-43	528.4					
1943-44	448.1	.8480	421.8	94.42	473,522	1,122.6
1943-44	508.7					
1944-45	507.1	.9969	420.5	94.13	548,415	1,304.2
1944-45	634.8					
1945-46	455.4	.7174	301.7	67.53	396,090	1,312.9
1945-46	464.2					
1946-47	235.4	.5071	153.0	34.24	227,470	1,486.7
1946-47	246.2					
1947-48	130.7	.5309	81.2	18.18	110,137	1,356.4
1947-48	123.4					
1948-49	263.5	2.1353	173.4	38.82	159,117	917.6
1948-49	217.9					
1949-50	442.8	2.0321	352.4	78.89	334,115	948.1
1949-50	434.1					
1950-51	282.1	.6499	229.0	51.27	350,548	1,530.8

TABLE 4

Average Lunar Month Catch for Monterey (in Tons)

Seasons	Average monthly catch		Linkage (Average monthly catch)		Total catch, tons	Total boat months
	Tons	Ratio	Tons	Percent		
1932-33	434.9	1.0055	680.6	123.04	89,257	131.1
1933-34	432.5					
1933-34	400.2	.6450	676.9	122.37	151,937	224.5
1934-35	620.5					
1934-35	604.5	1.4154	1,049.5	189.72	229,992	219.1
1935-36	427.1					
1935-36	518.8	.9422	741.5	134.04	184,113	248.3
1936-37	550.6					
1936-37	680.6	2.1538	787.0	142.26	206,229	262.0
1937-38	316.0					
1937-38	393.1	.6452	365.4	66.05	104,464	285.9
1938-39	609.3					
1938-39	603.6	.9611	566.3	102.37	180,090	318.0
1939-40	628.0					
1939-40	638.4	1.2853	589.2	106.51	227,231	385.7
1940-41	496.7					
1940-41	574.3	.8287	458.4	82.87	165,145	360.3
1941-42	693.0					
1941-42	553.2		553.2	100.00	249,717	451.4
1942-43	532.2	.9620	532.2	96.20	183,158	344.2
1942-43	499.4					
1943-44	529.8	1.0609	564.6	102.06	212,383	376.2
1943-44	678.5					
1944-45	629.3	.9275	523.7	94.66	234,613	448.0
1944-45	839.7					
1945-46	487.0	.5800	303.7	54.90	142,282	468.5
1945-46	556.9					
1946-47	120.3	.2160	65.6	11.86	26,790	408.4
1946-47	123.2					
1947-48	66.3	.5381	35.3	6.38	14,448	409.3
1947-48	38.5					
1948-49	127.7	3.3169	117.1	21.16	40,427	345.2
1948-49	161.3					
1949-50	606.8	3.7619	440.5	79.60	128,412	291.5
1949-50	718.6					
1950-51	143.0	.1990	87.7	15.84	32,077	365.8

TABLE 5

Average Lunar Month Catch for San Pedro (in Tons)

Seasons	Average monthly catch		Linkage (average monthly catch)		Total catch, tons	Total boat months
	Tons	Ratio	Tons	Percent		
1932-33 1933-34	335.3 452.7	.7407	578.4	174.26	83,492	144.3
1933-34 1934-35	420.1 450.9	.9317	780.9	235.27	126,438	161.9
1934-35 1935-36	404.3 286.4	1.4117	838.1	252.52	183,614	219.1
1935-36 1936-37	356.5 271.5	1.3131	593.7	178.88	148,822	250.7
1936-37 1937-38	281.8 172.9	1.6298	452.1	136.23	142,483	315.2
1937-38 1938-39	182.3 231.5	.7875	277.4	83.59	109,122	393.4
1938-39 1939-40	251.1 197.4	1.2720	352.3	106.15	148,125	420.5
1939-40 1940-41	210.2 307.6	.6834	277.0	83.45	93,176	336.4
1940-41 1941-42	383.8 314.3	1.2211	405.3	122.11	171,747	423.8
1941-42 1942-43	331.9 479.5	 1.4447	331.9 479.5	100.0 144.47	147,825 202,597	445.4 422.5
1942-43 1943-44	541.4 318.0	 .5874	 281.7	 84.86	 135,007	 479.3
1943-44 1944-45	308.1 490.3	 1.5914	 448.3	 135.05	 177,465	 395.9
1944-45 1945-46	509.3 446.3	 .8763	 392.8	 118.34	 170,325	 433.6
1945-46 1946-47	434.5 283.3	 .6520	 256.1	 77.16	 197,830	 772.5
1946-47 1947-48	297.5 134.2	 .4511	 115.5	 34.81	 95,314	 825.2
1947-48 1948-49	131.0 279.4	 2.1328	 246.3	 74.24	 117,321	 476.3
1948-49 1949-50	240.9 406.6	 1.6878	 415.7	 125.30	 188,168	 452.7
1949-50 1950-51	386.0 291.2	 .7544	 313.6	 94.53	 302,814	 965.6

TABLE 6

Average Lunar Month Catch for All California (in Numbers)

Seasons	Average monthly catch		Linkage (average monthly catch)		Total catch, numbers	Total boat months
	Numbers	Ratio	Numbers	Percent		
1932-33 1933-34	2,340,659 2,688,398	.8707	3,060,668	74.68	1,371,349,600	448.1
1933-34 1934-35	2,538,674 3,524,561	.7203	3,515,181	85.77	2,109,753,600	600.2
1934-35 1935-36	3,509,942 2,797,561	1.2546	4,880,163	119.07	3,497,064,900	716.6
1935-36 1936-37	3,106,098 2,867,485	1.0832	3,889,816	94.91	3,407,798,900	876.1
1936-37 1937-38	3,038,650 1,727,027	1.7595	3,591,041	87.62	4,441,916,800	1,236.9
1937-38 1938-39	1,885,135 3,091,803	.6097	2,040,944	49.80	2,788,745,600	1,366.4
1938-39 1939-40	3,172,131 2,975,969	1.0659	3,347,456	81.68	4,683,042,700	1,399.0
1939-40 1940-41	3,136,434 3,571,681	.8781	3,140,497	76.63	4,127,771,600	1,314.4
1940-41 1941-42	4,128,319 4,730,275	.8727	3,576,469	87.27	4,021,823,800	1,124.5
1941-42 1942-43	4,098,165 3,947,619	 .9633	4,098,165 3,947,762	100.00 96.33	5,343,901,500 3,988,448,700	1,304.0 1,010.3
1942-43 1943-44	4,193,651 3,270,803	 .7799	 3,078,860	 75.13	 3,453,436,700	 1,121.7
1943-44 1944-45	3,713,139 3,521,528	 .9484	 2,919,991	 71.25	 3,809,906,500	 1,304.8
1944-45 1945-46	4,408,333 3,207,042	 .7275	 2,124,293	 51.83	 2,792,801,200	 1,314.7
1945-46 1946-47	3,269,014 1,961,667	 .6001	 1,274,788	 31.10	 1,893,083,100	 1,485.0
1946-47 1947-48	2,051,667 1,098,319	 .5353	 682,394	 16.65	 926,939,400	 1,358.4
1947-48 1948-49	1,036,975 2,462,617	 2.3748	 1,620,549	 39.54	 1,492,529,400	 921.0
1948-49 1949-50	2,036,449 3,659,504	 1.7970	 2,912,127	 71.05	 2,757,132,000	 946.8
1949-50 1950-51	3,587,760 2,089,630	 .5824	 1,696,023	 41.38	 2,589,569,000	 1,526.8

TABLE 7

Average Lunar Month Catch for Monterey (in Numbers)

Seasons	Average monthly catch		Linkage (average monthly catch)		Total catch numbers	Total boat months
	Numbers	Ratio	Numbers	Percent		
1932-33	2,416,111	1.0223	3,781,510	71.77	495,872,200	131.1
1933-34	2,363,388					
1933-34	2,186,885	.6027	3,699,022	70.20	830,256,800	224.5
1934-35	3,628,655					
1934-35	3,535,088	1.3657	6,137,419	116.48	1,344,982,500	219.1
1935-36	2,588,485					
1935-36	3,144,242	.9251	4,493,973	85.29	1,117,868,900	248.7
1936-37	3,398,765					
1936-37	4,201,235	1.9145	4,857,824	92.20	1,273,018,500	262.1
1937-38	2,194,444					
1937-38	2,729,861	.5332	2,537,385	48.16	725,444,400	285.9
1938-39	5,120,168					
1938-39	5,072,269	1.0661	4,758,786	90.32	1,513,361,300	318.0
1939-40	4,757,576					
1939-40	4,836,364	1.1295	4,463,733	84.72	1,721,447,000	385.7
1940-41	4,281,897					
1940-41	4,950,862	.7501	3,951,955	75.01	1,423,663,800	360.2
1941-42	6,600,000					
1941-42	5,268,571		5,268,571	100.00	2,378,257,100	451.4
1942-43	3,884,672	.7373	3,884,517	73.73	1,336,919,700	344.2
1942-43	3,645,255					
1943-44	3,730,986	1.0235	3,975,803	75.46	1,495,654,900	376.2
1943-44	4,778,169					
1944-45	4,431,690	.9275	3,687,557	69.99	1,652,204,200	448.0
1944-45	5,913,380					
1945-46	3,062,893	.5180	1,910,155	36.25	894,855,300	468.5
1945-46	3,502,516					
1946-47	841,259	.2402	458,819	8.71	187,342,700	408.3
1946-47	861,538					
1947-48	602,727	.6996	320,990	6.09	131,233,800	408.8
1947-48	350,000					
1948-49	1,502,353	4.2924	1,377,817	26.14	474,660,832	344.5
1948-49	1,897,647					
1949-50	4,429,197	2.3340	3,215,825	61.01	937,304,000	291.5
1949-50	5,245,255					
1950-51	893,750	.1704	547,977	10.40	200,622,000	366.1

TABLE 8

Average Lunar Month Catch for San Pedro (in Numbers)

Seasons	Average monthly catch		Linkage (average monthly catch)		Total catch numbers	Total boat months
	Numbers	Ratio	Numbers	Percent		
1932-33 1933-34	2,044,512 2,829,375	.7226	3,526,725	103.06	509,097,600	144.4
1933-34 1934-35	2,625,625 3,006,000	.8735	4,880,605	142.63	789,776,500	161.8
1934-35 1935-36	2,695,333 2,031,206	1.3270	5,587,413	163.29	1,224,708,700	219.2
1935-36 1936-37	2,528,369 1,786,184	1.4155	4,210,560	123.05	1,053,331,100	250.2
1936-37 1937-38	1,853,947 1,372,222	1.3511	2,974,610	86.93	936,642,300	314.9
1937-38 1938-39	1,446,825 2,247,573	.6437	2,201,621	64.34	866,906,000	393.8
1938-39 1939-40	2,437,864 1,827,778	1.3338	3,420,259	99.95	1,437,404,800	420.3
1939-40 1940-41	1,946,296 3,076,000	.6327	2,564,297	74.94	862,740,700	336.4
1940-41 1941-42	3,838,000 3,240,206	1.1845	4,052,943	118.45	1,712,317,900	422.5
1941-42 1942-43	3,421,649 4,523,585	 1.3220	3,421,649 4,523,420	100.00 132.20	1,524,396,400 1,919,972,000	445.5 424.5
1942-43 1943-44	5,107,547 2,917,431	 .5712	 2,583,778	 75.51	 1,241,122,700	 480.4
1943-44 1944-45	2,826,606 4,052,066	 1.4335	 3,703,846	 108.24	 1,465,636,300	 395.7
1944-45 1945-46	4,208,264 3,782,203	 .8988	 3,329,017	 97.29	 1,444,233,900	 433.8
1945-46 1946-47	3,682,203 2,421,368	 .6576	 2,189,162	 63.98	 1,688,147,800	 771.1
1946-47 1947-48	2,542,735 1,118,333	 .4398	 962,793	 28.14	 792,379,900	 823.0
1947-48 1948-49	1,091,667 2,388,034	 2.1875	 2,106,110	 61.56	 1,003,782,326	 476.6
1948-49 1949-50	2,058,974 3,663,063	 1.7791	 3,746,980	 109.52	 1,698,032,000	 453.2
1949-50 1950-51	3,477,477 2,206,061	 .6344	 2,377,084	 69.48	 2,318,938,000	 975.5

RELATIVE STRENGTH OF VARIOUS YEAR CLASSES

Other studies indicate that the success of the season's fishing is largely dependent at present on two year classes, sardines about $2\frac{1}{2}$ and $3\frac{1}{2}$ years old. With only two year classes supplying three-fourths or more of the catch any major changes in the abundance of each year class is of material importance to the fishery. The data here presented, together with the data on numbers of fish taken from each year class each season given by Felin *et al.* (1948, 1949, 1950, 1951) and Mosher, Felin and Phillips (1949), furnish a measure of the relative abundance of each of 11 year classes, 1938-1948.

The numbers of fish taken in the California fishery from each of these year classes when $2\frac{1}{2}$ and $3\frac{1}{2}$ years old, as shown by Felin *et al.*, was divided by the total number of boat months in each specific season as given in Table 6. The result (Table 9) is the number of fish caught per lunar month for each year class and makes possible a direct comparison of the strength of these groups.

TABLE 9

Relative Size of Individual Year Classes Measured by the Number Taken Per Average Boat Month When Each Year Class Was Approximately 2½ and 3½ Years Old

Year class	Number per boat month	
	At 2½ years	At 3½ years
1938		1,194,000
1939	2,267,800	1,706,900
1940	1,020,200	860,100
1941	532,000	572,600
1942	952,000	637,300
1943	691,700	246,700
1944	350,300	126,600
1945	231,300	178,000
1946	824,400	811,700
1947	1,495,700	648,300
1948	734,500	
Average	910,000	698,200

The 1939 year class remains the outstanding group in the fishery, yielding 2,268,000 fish per month at $2\frac{1}{2}$ years and 1,707,000 at $3\frac{1}{2}$ years. The 1940, 1942, and 1946 year classes were about average and the 1947 gave promise at $2\frac{1}{2}$ years of being the largest since 1939. In the next season (1950-51), however, it dropped materially and can now be considered no better than average. At $2\frac{1}{2}$ years the 1948 class appears to be somewhat below average but considerably better than 1941, 1944, and 1945. It was the increase in numbers in the 1946 and 1947 year classes that produced improvements in fishing success in 1949-50 and the 1948 class did much to maintain the Southern California fishery in 1950-51.

REFERENCES

Clark, Frances N., and Anita E. Daugherty
1950. Average lunar month catch by California sardine fishermen, 1932-33 through 1948-49. Calif. Div. Fish and Game, Fish Bull. 76, 28 p.

Felin, Frances E., and Julius B. Phillips
1948. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada, 1941-42 through 1946-47. Calif. Div. Fish and Game, Fish Bull. 69, 122 p.

Felin, Frances E., Anita E. Daugherty and Leo Pinkas
1950. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada in 1949-50. Calif. Fish and Game, vol. 36, no. 3, p. 241-249.
1951. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada in 1950-51. Calif. Fish and Game, vol. 37, no. 3, p. 339-349.

Felin, Frances E., Julius B. Phillips and Anita E. Daugherty
1949. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada in 1948-49. Calif. Fish and Game, vol. 35, no. 3, p. 165-183.

Mosher, Kenneth H., Frances E. Felin and Julius B. Phillips
1949. Age and length composition of the sardine catch off the Pacific Coast of the United States and Canada in 1947-48. Calif. Fish and Game, vol. 35, no. 1, p. 15-40.

Silliman, Ralph P., and Frances N. Clark
1945. Catch per-unit-of-effort in California waters of the sardine (*Sardinops caerulea*) 1932-1942. Calif. Div. Fish and Game, Fish. Bull. 62, 76 p.

SARCOCYSTIS IN DEER AND ELK OF CALIFORNIA[1]

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INTRODUCTION

Sarcocystis is believed to be a protozoan parasite that is found chiefly in the striated muscles of mammals, birds, and reptiles. Recent reports (Spindler and Zimmerman, 1945; Spindler, 1947) state that *Sarcocystis* is a fungus rather than a protozoan. It appears as a whitish, spindleshaped body varying in length from microscopic to as large as five centimeters depending upon the host.

This parasite was first discovered by Miescher (1843) who described milk-white filaments in the striated muscles of domestic mice. Since that time it has been reported in over 45 hosts and numerous papers have been written about this organism, but our knowledge of its life cycle and distribution is very incomplete. It is believed that infection of a new host begins with the entrance of spores into the digestive tract. Once in the intestine the spore membrane ruptures and the liberated sporozoite penetrates the intestinal epithelium and makes its way into the muscle tissue by way of the blood stream. Among the mammals they have been found chiefly in swine, cattle and sheep in which as many as one hundred percent have been reported to be infected in some localities.

Sarcocystis in deer of California, *Odocoileus hemionus*, was first observed by Herman (unpublished report, 1948) in muscles of deer from Sequoia National Park in Tulare County on February 11-13, 1948. Forty to sixty percent of the deer were found to be infected. A few of the cysts were grossly visible but the majority required microscopic study of histological sections for diagnosis. An examination of muscle samples obtained from deer on a subsequent field trip to the same area on April 5-9, 1948, presented a similar picture. A year later in April, 1949, a more extensive investigation of this parasite in the deer of California was initiated. Since a special hunting season was being granted in 1949 for the taking of antelope and elk, an examination for *Sarcocystis* in both of these animals was included in this study.

ACKNOWLEDGMENTS

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The author is indebted also to Dr. Harold Kirby, Chairman of the Department of Zoology, University of California, whose interest, help and encouragement in this study has made its completion possible.

Finally, acknowledgement is made to the personnel of the Disease Laboratory, to the captains and wardens and other fish and game personnel who have aided in the collection of muscle samples in the field.

MATERIALS AND METHODS

Muscle samples were obtained from several sources. However, the majority were collected by personnel of the Bureau of Patrol, California Department of Fish and Game. Others were procured from hunters during the deer season which extended from August 7-September 15, 1949, in some areas of California and from September 16-October 15, 1949, in other areas. Specimens were preserved in 10 percent formalin until processed.

A total of 1,062 deer muscle samples was collected. Included in these were 52 samples obtained from deer on Santa Catalina Island, Los Angeles County, during a special hunting season, which extended from November 1, 1949 to January 31, 1950.

In addition to deer, samples were obtained from 73 antelope, *Antilocapra americana*, and 36 elk, *Cervus nannodes*. The former were collected in Modoc and Lassen Counties between August 27 and September 5, 1949, and the latter in Inyo County between December 2-11, 1949.

All samples were fixed in 10 percent formalin, dehydrated, embedded in paraffin, cut eight micra thick and stained with hematoxylin and eosin. Completed slides were first examined under a dissecting microscope using a 9x ocular and 3x objective. This proved to be the most rapid method of picking out the positive cases and making a count of the number of cysts. Slides negative by this procedure were further examined under a compound microscope using 5x ocular and low power objective, scanning the entire section with a mechanical stage.

Following the preliminary counting of cysts by means of the dissecting and low power microscope, oil immersion was used to make a more detailed morphological study of the cysts.

RESULTS

Description of *Sarcocystis* in Deer and Elk of California

One of the earliest accounts of *Sarcocystis* in deer is that made by Hessling (1854), who reported the finding of so-called "Miescher's tubes" in the striated muscles of sheep, cattle and deer. The author, however, has been unable to find any published reference on the occurrence of *Sarcocystis* in North American Cervidae.

Although it is quite difficult to detect the presence of *Sarcocystis* in the muscle of deer with the unaided eye, except in extremely heavy infections, it is quite simple to observe the cysts under a dissecting microscope. They appear as small, whitish, cylindrical and fusiform bodies lying embedded in and parallel with the muscle fibers and standing out against the pinkish and glistening background of the muscle tissue. The cysts are comparatively small in size varying from a fraction of a millimeter to several millimeters in length. None has been observed to have a length

as great as 1 or 2 centimeters as is commonly found in waterfowl. The appearance of the sarcocyst varies depending upon its location in the body, its age, and the nature of the enclosing tissue. In general, the majority of the mature cysts measured 40 to 70 micra in diameter with a thin compact wall 1 to 2 micra thick. Occasionally, an exceptionally large cyst having a more complex wall structure was observed. These cysts measured about 100 micra in diameter. The cyst wall was rather thick, measuring 5 to 6 micra thick and the outer envelope was radially striated.

A cyst which was cut at an angle showed this outer envelope to have a honeycomb-like structure. Surrounding the outer envelope was a uniform layer of muscle 7 to 8 micra thick with the muscle nuclei located peripherally. Inside the wall was a thin hyaline membrane 1 to 2 micra thick. The interior of the cyst was divided into numerous compartments which were visible in few of the cysts. The compartments were not all of uniform size, the peripheral compartments being smaller than the more centrally located ones. The peripheral compartments contained more spherical sporoblast cells while the center compartments contained crescent-shaped spores. The spores themselves were quite uniform in size as well as in morphology. They were all crescentric in shape, one end of which was rounded and the other pointed. They measured 9 to 10 micra in linear length and 3 micra in width. In some of the spores, a darkly staining nucleus was observed at the rounded end while the pointed end was clear with a mass of deeply staining granules between. No difference in the morphology of the spore itself was noted whether it was found in the tongue, diaphragm or thigh, but there was some variation in the shape of the cyst itself depending on its location within the deer. This was especially true of the cysts found in the tongue muscle which had an irregular appearance both in cross section and longitudinal section. This probably can be explained by the irregular pattern of the tongue muscle fibers.

Of the 36 elk samples, 55 percent were found to be infected with *Sarcocystis*. The cysts in elk were uniformly small in diameter ranging from 30 to 70 micra while the length varied from 100 to 150 micra. In addition to its comparatively small size, the intensity of the infection in elk was extremely light as compared with that found in the deer. All except one of the 20 positive cases had a count of one or two cysts per section. The only exception had 10 cysts. In contrast to this, two deer muscle samples were found with a count of approximately 200 cysts in an area of tissue of a similar size. The majority of the cysts observed in elk had a cyst wall which was consistently compact with a uniformly thin layer of muscle surrounding it. The wide variation in the structure of the cyst wall observed in the deer was absent. The spore itself, however, was quite similar to that observed in the deer. Its dimensions were 3 micra wide and 9 to 10 micra long. The length represented a linear rather than a curved measurement. No observable difference was noticed in the morphology of the spore found in the deer and elk.

Muscle samples from the tongue, diaphragm and thigh of the 73 antelope were sectioned and examined. Although a careful search for the parasite was made, not a single cyst was found.

Distribution of *Sarcocystis* Within the Deer

It is generally agreed that *Sarcocystis* is found chiefly in striated muscle. Occasionally it has been reported to occur in connective tissue. Various skeletal muscles from adult deer including tongue, eye, neck, diaphragm, and thigh, as well as heart muscle, were sectioned and examined. *Sarcocystis* was found to occur in all these locations.

A further study was made by comparing ham, tongue and diaphragm muscles taken from 30 deer. Sixty percent were either all positive, or all negative. An additional 23 percent were positive in both tongue and thigh but negative in the diaphragm. The remaining 17 percent were infections of low intensity. Thus it appears that good correlation exists between tongue and thigh and among the three, provided the intensity of the infection is not too low.

Since the cysts can be found in such diversely located parts of the animal as in the tongue, diaphragm and thigh simultaneously, as well as in the eye, neck and heart muscle, it can safely be concluded that sarcosporidiosis is a generalized rather than a localized infection of the skeletal muscles of deer.

Distribution of *Sarcocystis* in Deer of Different Ages

Numerous experiments have been carried out in the lamb, sheep, calf and pig on the life history of *Sarcocystis* concerning the age and time of year at which the animals are naturally infected and its relation to the life cycle of the parasite. The general conclusion was that the youngest age at which infection occurred was between 6 and 10 weeks and that the youngest cysts were found in the spring.

A similar situation was found in the deer. A total of 82 deer muscle samples, including 15 fawns, were collected in Contra Costa and Alameda Counties between April 1 and the beginning of the deer season on August 7, 1949. As the tissues were examined as they arrived at the laboratory, it was soon noticed that the majority of the fawns were negative while all the yearlings and adults were positive. An inspection of the findings showed that the first positive case among fawns was collected on July 25, 1949, from Alamo, Contra Costa County. Up to that time 65 yearling and adult muscle samples and eight fawn samples had been received, all of the former being positive and all of the fawns being negative. Since the young are dropped sometime during April and May in Alameda and Contra Costa Counties, a period of two or three months elapsed before the first positive case was detected in a fawn. This observation is in agreement with those made by other workers discussed above in which they came to the general conclusion that the youngest age at which infection occurred was between 6 and 10 weeks.

Incidence and Geographical Distribution of *Sarcocystis* in Deer of California

In contrast to the varied opinion among the workers as to the mode of transmission of *Sarcocystis*, they agree on its widespread prevalence and high rate of incidence. A similar situation was found to exist in deer of California. A total of 1,062 deer muscles was collected from 40 of the 58 counties of California, of which 877 were successfully sectioned. These data are tabulated by counties in Table 1. Excluding the 31 fawns,

577 of the 846 yearlings and adults or 68 percent were found to be positive for *Sarcocystis*. This value is very likely an underestimation as to what actually exists in nature, since the detection of a positive case was based on the examination of a single section of tissue approximately one centimeter square and eight micra thick.

Although an insufficient number of samples was obtained, indications are that *Sarcocystis* in deer occurs thorughout all of California with an incidence rate ranging roughly from 60 to 90 percent.

Pathogenicity

There is a wide difference of opinion as to the general pathological effects produced by this parasite. Some workers believe that sarcosporidiosis causes no ill effects, while others believe that it results in severe illness and even death if a large number of sarcocysts are present. Since it was not possible to obtain a full autopsy report on each deer to compare with the histological findings, no concrete evidence relating to the pathological effects of *Sarcocystis* in deer can be presented. However, correlating a 68 percent infection rate with the fact that the majority of these were shot by hunters who would hesitate at taking a deer that was sick or in poor condition, it can be surmised that an infection of low intensity has very litte effect on the general health of the deer.

Since deer is the major game mammal in California, approximately 52,000 having been reported taken, according to deer tag returns, during the 1949 season, the transmissibility of *Sarcocystis* to man through the ingestion of venison becomes a problem of practical importance. Furthermore, the majority of the human population also ingests pork, beef, and mutton which are just as heavily, if not more, infected with *Sarcocystis* as are the deer. Although it would be quite difficult to subject this problem to direct experimentation, a search through the literature shows that the majority of the writers conclude that sarcosporidial infection in man is rare.

SUMMARY

A total of 1,062 deer muscle samples, of which 877 were successfully sectioned, was collected from 40 of the 58 counties of California during the course of study which extended from April 1, 1949, to March 31, 1950. Excluding 31 fawns, 68 percent of the yearlings and adults were found to be positive for *Sarcocystis*. No difference in the rate of incidence was observed for any particular region of the State.

Various skeletal muscles from adult deer including tongue, eye, neck, diaphragm and thigh as well as heart were examined. *Sarcocystis* was found to occur in all these locations.

Fawns were found to be negative for *Sarcocystis* for a period of two or three months following their birth.

Samples were collected from 36 elk. Fifty-five percent were found to be infected with *Sarcocystis* although the intensity of the infection was very low as compared to the deer.

In addition to deer and elk, 73 antelope samples were collected and sectioned. Although a careful search for *Sarcocystis* was made, not a single cyst was found.

TABLE 1

Tabulation of Deer Muscle Samples Collected

County	Total examined	Fawn		Yearling and adult		Percentage positive yearling and adult
		Pos.	Neg.	Pos.	Neg.	
Alameda	32	1	4	24	3	89
Alpine	42			28	14	67
Amador	27			23	4	85
Calaveras	26			21	5	81
Colusa	2			1	1	
Contra Costa	72	2	15	50	5	91
El Dorado	23			15	8	65
Fresno	10			9	1	
Humboldt	2			2		
Inyo	12			9	3	
Kern	3			3		
Lake	66		1	35	30	54
Lassen	14			8	6	
Los Angeles	43	1		31	11	72
Santa Catalina Island	47		2	18	27	40
Madera	2			2		
Marin	10			7	3	
Mendocino	5			5		
Merced	1			1		
Modoc	5			3	2	
Mono	47			35	12	74
Monterey	4			3	1	
Napa	3	1	2			
Nevada	1				1	
Placer	2			1	1	
Plumas	7			2	5	
Riverside	57			35	22	61
San Bernardino	44			32	12	73
San Mateo	26			18	8	69
Santa Barbara	1			1		
Santa Clara	2			2		
Santa Cruz	1		1			
Shasta	5			3	2	
Sierra	3			1	2	
Siskiyou	1			1		
Sonoma	25			20	5	80
Stanislaus	10			8	2	
Tehama	30	1		22	7	76
Trinity	40			20	20	50
Tuolumne	123			77	46	63
Ventura	1			1		
Totals	877	6	25	577	269	

LITERATURE CITED

Hesseling, Th.
1854. Histologische Mitteilungen. Zeitschr. Wiss. Zool., vol. 5, p. 189.

Miescher, F.
1843. Uber eigenthumliche Schlauche in den Muskeln einer Hausmaus. Naturf. Gesell, in Basel. Ber. uber die Verhandl., vol. 5, p. 198.

Scott, J. W.
1930. The Sarcosporidia: a critical review. Journ. Parasitol., vol. 16, p. 111-130.

Spindler, L. A.
1947. A note on the fungoid nature of certain internal structure of Miescher's sacs (*Sarcocystis*) from a naturally infected sheep and a naturally infected duck. Proc. Helminth. Soc. Wash., vol. 14, p. 28-30.

Spindler, L. A. and H. E. Zimmerman, Jr.
1945. The biological status of *Sarcocystis*. Journ. Parasitol., vol. 31, suppl., p. 13.

Wenyon, C. M.
1926. Protozoology, vol. 1, p. 760-769. N. Y., William Wood and Co.

AN ANALYSIS OF SILVER SALMON COUNTS AT BENBOW DAM, SOUTH FORK OF EEL RIVER, CALIFORNIA[1]

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INTRODUCTION

Each year the Bureau of Fish Conservation of the Department of Fish and Game counts the salmon and steelhead which ascend the fishway at Benbow Dam, on the South Fork of Eel River near Garberville, Humboldt County. This long-range project was inaugurated by Messrs. A. C. Taft and Leo Shapovalov, and the counts have been made annually since the season of 1938-39. Summaries of the counts have been issued in mimeographed form at yearly intervals. However, as with many similar projects, it has been necessary to await the completion of several salmonid cycles before detailed analyses of the data would prove fruitful. The first of these analyses, a preliminary one of the counts at this and other stations for the counting seasons 1938-39 through 1949-50, has been presented in another paper (Murphy and Shapovalov, 1951).

In the present paper the counts of a single species, the silver salmon (*Oncorhynchus kisutch*), are given in detail for the seasons 1938-39 through 1950-51. A method is given for calculating the absolute number in each age class at the end of the first season of ocean life; for calculating the percentage of each age class that returned as grilse (males with one season in fresh water and one season in the ocean); and for calculating the percentage of mortality during the final year of life of the silver salmon. In addition, an attempt is made to explain fluctuations in the population by use of correlation analysis.

METHODS OF COUNTING

Counts are made of fish passing the fishway over Benbow Dam. A white board 24 inches in length is placed on the wall separating two pools and the fish either jump or swim over the board. An observer is stationed about eight feet above and slightly downstream from the board. Counts are made during daylight hours only.

Silver salmon are segregated as grilse, males, and females. All judged to be 24 inches or less in length (by comparing them with the board) are classed as grilse. Benbow Dam is located about 80 miles upstream from the ocean, and by the time that the salmon have reached the dam they have generally assumed most of their secondary sexual characteristics.

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[2] Now with U. S. Fish and Wildlife Service, P. O. F. I., Honolulu, T. H.

TABLE 1

Silver Salmon Counts at Benbow Dam

Counting season	Males	Females	Grilse	Total
1938-39	3,194	2,844	1,332	7,370
1939-40	2,572	2,861	3,196	8,629
1940-41	3,540	4,698	2,835	11,073
1941-42	4,068	5,184	4,442	13,694
1942-43	4,415	6,674	3,948	15,037
1943-44	4,351	6,363	2,316	13,030
1944-45	7,137	8,022	3,150	18,309
1945-46	6,392	7,729	2,610	16,731
1946-47	4,972	5,840	3,297	14,109
1947-48	9,708	11,583	3,998	25,289
1948-49	5,032	5,824	2,016	12,872
1949-50	2,527	2,963	2,005	7,495
1950-51	4,292	4,609	3,149	12,050

For this reason identification of males and females is usually easy. At times, though, the sexes are not so readily distinguishable. Some confusion of silver salmon with steelhead, particularly in the grilse counts, may also have taken place. The counts just described for the counting seasons 1938-39 to 1950-51 are given in Table 1. It should be noted that considerable numbers of silver salmon also spawn in the reaches below Benbow Dam.

INTERPRETATION OF THE COUNTS

A. C. Taft and Leo Shapovalov (unpublished data), working with marked silver salmon at Waddell Creek, California, found without exception that they spent one year in fresh water, one season in the ocean if they returned as grilse, and two seasons if they returned as adults. Other workers (Marr, 1943; Pritchard, 1936 and 1940) have found slight variations of this pattern, but these studies were conducted without the benefit of marked fish. Because of the regular life history pattern evinced by the silver salmon, at least in California, we can use the data in Table 1 to calculate the number of fish in each age class at the end of the first season of ocean life (when the grilse migrate to fresh water). The following formula is first solved for the survival of each age class during its last year of ocean life, in which *s* is survival, *n* any particular counting season, and *n*-1 the previous counting season.

$$s = \frac{♀\, n - ♂\, n}{♂\, n\text{-}1}$$

The numbers of males and females in the numerator are the numbers of three-year-olds counted at year *n*, and the denominator, grilse counted at year *n*-1. Once the survival, *s*, is known it can be divided into the number of females at year *n* to give the total number of females in the ocean at year *n*-1. The number of males at year *n*-1 (before the grilse migration) is assumed to equal the number of females. Once the number of fish at age *n*-1 is known it is a simple matter to calculate the percentage of males that return as grilse. These calculations can be made for the runs of 1939-40 to 1950-51, and are given in Table 2.

TABLE 2

Calculated Statistics on Benbow Dam Silver Salmon

Year (n)	Calculated numbers at year n-1			Percentage	
	Males	Females	Total	Survival during last ocean year	Males running as grilse
1939-40	13,184	13,184	26,368	21.7	10.1
1940-41	12,977	12,977	25,954	36.2	24.6
1941-42	13,157	13,157	26,314	39.4	21.5
1942-43	13,138	13,138	26,276	50.8	33.8
1943-44	12,476	12,476	24,952	51.0	31.6
1944-45	21,000	21,000	42,000	38.2	11.0
1945-46	18,229	18,229	36,458	42.4	17.3
1946-47	17,538	17,538	35,076	33.3	14.9
1947-48	20,357	20,357	40,714	56.9	16.2
1948-49	29,414	29,414	58,828	19.8	13.6
1949-50	13,718	13,718	27,436	21.6	14.7
1950-51	29,171	29,171	58,342	15.8	6.9
Mean	----------	----------	----------	35.6[1] 33.0[2]	18.0[1]

[1] Arithmetic mean.
[2] Geometric mean.

We should note that certain assumptions must be made in accepting the operations in Table 2. They are:

1. A one to one sex ratio in downstream migrating silver salmon.
2. Equal mortality of males and females in the ocean and in the stream until they pass the counting station.

The first assumption is probably met whenever large numbers of migrants are concerned. It might not be met when dealing with small numbers of fishes, but on the other hand could be readily tested for any group of downstream migrants. The second assumption is not readily susceptible to test, but I know of no data indicating contrariwise.

In addition to possible failure to meet these basic assumptions, there are two other potential sources of error. Straying rates may vary between grilse and adults from the same brood. This error should not be serious, since the amount of straying among silver salmon is relatively small. Sexing of adults may not be accurate. For instance, the calculated number at n-1 for the 1950-51 run would be only 37,000 if only 100 of the females for that year were misclassified as males, without a compensating error in the other direction. This sort of error may affect the Benbow Dam counts, but it does not invalidate the method. A final source of error would be mortality among grilse on their fresh-water migration to the counting station. There is no commercial fishery in the Eel River and sportsmen apparently do not capture many silver salmon grilse, so this error is probably slight in the data under consideration. As pointed out above, failure to correctly sex the migrants can lead to serious error in the calculations. The first year's count had an excess of males over females.

This was probably due to misidentification, although there is no substantiating evidence. Referring to Table 2, the following correlations are obtained:

1. Total n-1 population and percentage of survival during the last year in the ocean. ($r = -.426$, $p > 5$ percent)
2. Survival in the last ocean year and percentage of males running as grilse. ($r = .682$, $p < 5$ percent)
3. Total n-1 population and percentage of males running as grilse. ($r = -.617$, $p < 5$ percent)

The most likely appearing explanation of these correlations is misclassification of the adults at the counting station. For example, if in a given year too many fish are counted as females, then the percentage grilsing and the survival are too high and the n-1 population too low. If the degree of inaccuracy varies from year to year, the three aforementioned correlations would result.

There is no reason to presume a systematic bias in the misclassification of males and females from year to year, and if the errors are random, their only effect will be to make the mortality rate and grilsing rate more variable. The mean of the 12 sets of data may then very closely approximate the true mean over the 12 years. The arithmetic mean of the grilsing rate is 18.0 percent and of the survival rate over the last year of life 35.6 percent.

Using the geometric mean of the survival rate during the last year in the ocean (33.0 percent) as the best estimate of survival each year, the n-1 population was recalculated, and from this the percentage of grilsing recalculated for each year. The new grilsing percentages range from 9.4 to 22.7, with an arithmetic mean of 17.1 percent. This treatment, then, has lessened the grilsing variability, believed due in part to misclassification of the sexes. Or, paraphrased, since misclassification of sexes leads to variation in calculated survival rates, and this in turn to variation in calculated grilsing, utilizing a mean survival rate inherently introduces a mean ratio of males to females, and results in what might be regarded as an improvement in the estimate of variability of grilsing.

Another procedure is to utilize a constant rate of grilsing (17.1 percent) and calculate a new set of n-1 population estimates by multiplying the n-1 grilse by 1/.171. From these, new survival estimates can be calculated. This might be desirable if one assumed rate of grilsing was relatively constant from year to year, with most or all of the variation due to misclassification of the sexes. The new estimates of percentage of survival range from 24.9 to 59.2, with an arithmetic mean of 36.3.

It is obvious from the discussion above that the methods presented offer the possibility of following a group of marked hatchery fish very precisely. The number and sex ratio of the downstream migrants could be known; the ocean mortality due to the fishery could be estimated from the catch of marked fish; the size of the population after the first season of ocean life and total survival and mortality during that year could be calculated; and finally the nonfishing mortality during the last year in the ocean could be calculated.

FACTORS RESPONSIBLE FOR FLUCTUATIONS IN THE SIZE OF THE POPULATION

The life history of the silver salmon can be divided into ocean and fresh-water phases. The question might be asked, "What factors are responsible for fluctuations in the runs?" One tool for exploring this question is correlation. If some factor that reason or ecological knowledge leads us to believe can control the population is significantly correlated with the measured population fluctuations, we can conclude that that factor is responsible for part of the fluctuation in that particular population at that particular population level.

In part due to lack of knowledge of the ocean ecology of silver salmon, we cannot apply correlation analysis to the ocean phase of its life. The fresh-water life is more susceptible to analysis. Such a study is handicapped by the limited number of years for which observations are available. A factor that does control the run to a moderate extent might give a parameter correlation coefficient of only .40. Such a correlation would not be significant at the 5 percent level unless 25 paired sets of observations were available. With only 13 seasons of records available for Benbow Dam, we must either locate factors that are strongly controlling the population or tentatively accept correlations that are not significant in the statistical sense.

Other workers, such as McKernan, Johnson, and Hodges (1950), have not had great success in locating factors significantly correlated with the size of the runs. Part of their difficulty may have been due to inexactness of their measure of abundance and spawning escapement (the commercial catch). This does not apply to the Benbow Dam data.

We would expect to find the best correlations with fresh-water factors by relating them to the numbers of downstream migrants. The next best might be obtained from the numbers in the ocean after one season of life, and the poorest by relating them to the spawning escapements. This is obvious, since factors operating in the ocean are probably independent of stream factors. Counts of downstream migrants are not available for Benbow Dam. The other two measures are available, so both were related to the factors being tested. Further, it was felt that if improvement in the correlations resulted from using the calculated n-1 populations, it would indicate reliability of the method and accuracy of the calculations in Table 2. Four factors were selected for analysis because measurements are available and because they could reasonably affect the relative size of the population. No factors were studied and later rejected. These factors are: number of eggs deposited, i.e., number of spawning females; total runoff during November and December (the spawning period); total runoff during September (the critical low flow month); and total runoff during January and February.

The correlations obtained are given in Table 3. Flow data are from the main Eel River at Scotia, but flows there are almost an exact reflection of relative flows in the entire Eel River basin. Flows in November and December, the principal spawning months, should operate by controlling the amount of spawning beds available, by influencing the upstream penetration of the fish, and by influencing the dispersal of the young fish

TABLE 3

Correlations of Population Size and Various Factors

Factors related	Period included	Number of seasons	Coefficient of correlation	Probability of significance
n[1] females—parent females (n-3)	1941-42 to 1950-51	10	.043	>.05
n-1 population—parent females (n-3)	1941-42 to 1950-51	10	.820	<.01
n females—Nov. Dec. flow (n-3)	1938-39 to 1950-51	13	.292	>.05
n-1 population—Nov. Dec. flow (n-3)	1939-40 to 1950-51	12	.283	>.05
n females—Sept. flow (n-2)	1938-39 to 1950-51	13	.068	>.05
n-1 population—Sept. flow (n-2)	1939-40 to 1950-51	12	.415	>.05
n females—Jan. Feb. flow (n-2)	1939-40 to 1950-51	12	.353	>.05
n-1 population—Jan. Feb. flow (n-2)	1939-40 to 1950-51	12	—.226	>.05
n females—Nov. Dec. flow (n-3)	1941-42 to 1950-51	10	.300	>.05
n-1 population—Nov. Dec. flow (n-3)	1941-42 to 1950-51	10	.411	>.05
n females—Nov. Dec. flow (n)	1941-42 to 1950-51	10	.027	>.05
n females—Nov. Dec. flow (n-3) and parent females (n-3)	1941-42 to 1950-51	10	.302	>.05
n-1 population—Nov. Dec. flow (n-3) and parent females (n-3)	1941-42 to 1950-51	10	.915	<.01

[1] n is the year the adult 3-year-old females returned to Benbow Dam.

during their year in fresh water. Flows in September should operate on the young fish by controlling the temperatures, the amount of stranding, and the amount of crowding in the streams. The manner of operation of egg deposition (number of spawning females) is obvious. January and February flows should affect the size of the hatch, i.e., excessively high flows might destroy redds and sweep newly risen young into unfavorable ecological sites or merely out of their parent streams.

In addition to the simple correlations one multiple regression involving the n and n-1 populations versus the egg deposition and the November-December flow was calculated. Others were not attempted because the reduction in degrees of freedom with only 10 matching sets of data forces the level of statistical significance impossibly high.

Turning to Table 3 we see that the only significant coefficients are the n-1 populations versus egg depositions (probability less than 1 percent) and the multiple correlation (probability less than 1 percent). Correlations for some other factors that might influence the sizes of the populations are interesting but not statistically significant. From Table 3 we could conclude that 67 percent of the variation in the n-1 population was due to variation in egg deposition, and that 85 percent was due to a combination of egg deposition and flow at the time of spawning.

It is worth noting that if the true correlation between egg deposition (escapment) and the n-1 population is .820, this population of silver salmon is being held at an inefficient level, presumably by commercial and sport fishing. As already noted an r of .820 indicated that 67 percent of the variation in the n-1 population is due to variation in spawning escapement. It follows that there is a very good chance of increasing the population available for exploitation by increasing the escapement.

As indicated in Table 3, four paired sets of correlations were calculated. Each pair consists of a factor or set of factors correlated with the n females and the same factors correlated with the n-1 populations.

(Females were used to represent the n population or spawning escapement, since they are unaffected by grilsing.) Though many of the correlation coefficients are not significant, in each instance the r was improved by using the calculated n-1 population instead of the n population (improved in that the correlation changed in the direction indicated by prior reasoning). For instance, the correlation involving January and February flows and the n population was .353; when the n-1 population was used the r became —0.226. If the n-1 calculations are essentially correct this might be expected, and if the figures in Table 2 do not represent the populations at n-1, the observed improvement in the four sets of coefficients has a probability of occurring by chance of only 6 percent. This line of reasoning, then, tends to lend confidence in the data shown in Table 2, even though the calculated statistics are probably too variable.

SUMMARY

Silver salmon (*Oncorhynchus kisutch*) have been counted at Benbow Dam, Humboldt County, California, from 1938 through 1950. During each of the 12 seasons the fish were segregated as grilse (males with one year in fresh water and one season in the ocean) and male and female adults (fish with one year in fresh water and two seasons in the ocean). Because a known number of fish of one sex (the grilse) are withdrawn from the ocean population at the end of the first ocean season it was possible to utilize the numerical sex differential in the three-year-old fish to estimate the survival during any particular year class' last season in the ocean by dividing the excess of females over males of any particular counting season by the number of grilse counted during the previous season.

This method was applied to each year class and from the survival the absolute size of the n-1 population and the percentage of grilsing were calculated.

The estimated survivals ranged from 15.8 to 56.9 percent, with a mean of 35.6 percent. The best estimated grilsing rates ranged from 6.9 to 33.8 percent with a mean of 18 percent. Some of the variability in survival and grilsing rates is believed to be due to inaccurate sex classification of the adults.

By correlation analysis the effect of the following factors on the population was studied: total egg deposition; runoff during the spawning season; runoff during the late incubation and hatching season; and runoff during the dry season. These four factors were related to both the observed number of females and the calculated population at the end of one ocean season for the same year class. Statistically significant correlation coefficients were obtained for egg deposition and size of the population after one ocean season and a multiple correlation of spawning season runoff and egg deposition versus the population at the end of one ocean season. Other correlation coefficients were not statistically significant, but with few sets of data available only strong controlling factors would be expected to show statistical significance.

In each instance the correlation coefficient was improved in the expected direction when the calculated population after one ocean season was used instead of the observed counts of females at the dam. This is in line with

prior expectation, since mortality over the final season in the ocean should be independent of stream factors. This observation lends credence to the calculated populations at the end of one ocean year.

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LITERATURE CITED

Marr, John C.
1943. Age, length, and weight studies of three species of Columbia River salmon (*Oncorhynchus keta, O. gorbuscha, and O. kisutch*). Stanford Ichthyological Bulletin, vol. 2, no. 6, p. 157-197.

McKernan, Donald L., Donald C. Johnson and John I. Hodges
1950. Some factors influencing the trends of salmon populations in Oregon. Fifteenth North American Wildlife Conf., Trans. p. 427-449.

Murphy, Garth I. and Leo Shapovalov
1951. A preliminary analysis of Northern California salmon and steelhead runs. Calif. Fish and Game, vol. 37, no. 4, p. 497-507.

Pritchard, A. L.
1936. Facts concerning the coho salmon (*Oncorhynchus kisutch*) in the commercial catches of British Columbia as determined from their scales. Pacific Biol. Station and Pacific Fisheries Exp. Station, Progress Repts., no. 29, p. 16-20.
1940. Studies on the age of the coho salmon (*Oncorhynchus kisutch*) and the spring salmon (*O. tschawytscha*) in British Columbia. Roy. Soc. Canada. Trans., ser. 3, vol. 34, sect. 5, 1940, p. 99-120.

AN ANNOTATED CHECK LIST OF THE FISHES OF NEVADA[1]

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These notes provide the first exhaustive list of Nevada fishes to appear in print, and are intended as the basis for a more comprehensive report on the fish fauna of the State. Progress has been made on the latter, but some time will pass before its completion. We have followed the outline of Shapovalov and Dill (1950) for uniformity and have utilized their proposed official common names in nearly all cases. A double asterisk (**) has been used to indicate introduced species, while a single asterisk (*) denotes native fishes which have been known to be planted in parts of the State where they did not originally belong.

Without the work and interest of certain individuals, even so simple a thing as the following list would not be possible of completion. Foremost among these are Drs. Carl L. Hubbs and Robert R. Miller, who have collected and studied the fishes of Nevada for many years, and who have been responsible for producing a logical continuity from what was long a fine ichthyological tangle. Particular thanks are due Dr. Miller for the subsequent interest he has shown in our efforts to promote a better understanding of the fish fauna of the State. His many comments and notations received in correspondence have solved many of our problems.

Cooperative efforts of the University of Nevada Museum of Biology and the State Fish and Game Commission over the past several years have resulted in innumerable additions to the Museum collection, to a point where a comprehensive assemblage of Nevada fishes now exists here for the first time.

CHECK LIST

Native Species and Established Exotic Species

Of the following 55 species, 21 are introduced.

Family Salmonidae. The Salmon and Trout Family.

1. *Oncorhynchus tshawytscha* (Walbaum). King Salmon.*

   Formerly, at least, this species ascended the rivers Owyhee, Bruneau, Jarbridge and Salmon in northeastern Nevada, tributaries to the Snake. Unsuccessfully planted in west-central Nevada.

2. *Oncorhynchus nerka* (Walbaum). Red Salmon.**

   2a. *Oncorhynchus nerka kennerlyi* (Suckley). Kokanee Red Salmon.**

   This landlocked variety of the Red Salmon is currently being planted in Lake Tahoe, Walker and Pyramid Lakes. It has maintained itself in the vicinity of Tahoe for several years (Donner Lake), but its establishment in the

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remnant lakes of Pleistocene Lake Lahontan in west-central Nevada is still uncertain.

3. *Salmo trutta* Linné. Brown Trout.**

3a. *Salmo trutta fario* Linné. Brown Trout.**

Widely planted and established in the Lahontan drainage of western and central Nevada. As the Truckee River, beginning at Lake Tahoe and ending in Pyramid Lake, slowly changes from a fresh, sparkling, cold, mountain cutthroat trout stream to a dammed-up, silted-up, warmed-up polluted stream, the Brown Trout has become increasingly the most important game fish, in spite of the fact that the Rainbow Trout has been most often planted there over the years.

While both this variety and the Loch Leven Trout (*S. trutta levenensis* Walker) have undoubtedly been planted in the State, hatchery practice has mixed the two to such an extent it is no longer practicable to attempt to separate them. Miller and Alcorn (1945) nominally referred all Nevada specimens known to them to *S. t. fario*.

4. *Salmo clarki* Richardson. Cutthroat Trout.

4a. *Salmo clarki henshawi* Gill & Jordan. Lahontan Cutthroat Trout.*

The form native to the Lahontan basin of Nevada. Now extinct in many places where it was formerly abundant, such as Pyramid Lake. Mixed by hatchery practice with other varieties, such as the Yellowstone cutthroat, and with the rainbow. A population existing in Summit Lake, Humboldt County, Nevada, may be the only pure strain of the Lahontan Cutthroat Trout left—there is some evidence, meager as yet, that it may have been introduced from Pyramid Lake many years ago by the Indians.

4b. *Salmo clarki lewisi* (Girard). Yellowstone Cutthroat Trout.**

Long a popular hatchery fish, this variety has been widely disseminated in Nevada over a period of many years.

4c. *Salmo clarki utah* (Suckley). Utah Lake Cutthroat Trout.**

Like the preceding subspecies, *S. c. utah* probably does not exist in pure strain in Nevada at the present time, since east-central Nevada, where it was originally introduced from Utah Lake, has also been planted with the other two varieties of *S. clarki*.

5. *Salmo gairdneri* Richardson. Rainbow Trout.**

5a. *Salmo gairdneri irideus* Gibbons. Southcoast Rainbow Trout.**

Without doubt, the rainbow has been the most popular and widely disseminated of hatchery trout—within our own State it has often been planted to the exclusion of other trout, and in New Zealand and India, among other countries, it now provides added zest to the sport of fishing. It hybridizes readily with the cutthroat to the disadvantage of the latter, even in streams where the cutthroat is the better adapted of the two species if either were present alone. Hardly a Nevada stream exists which has not, at one time or another, been planted with rainbow.

5b. *Salmo gairdneri regalis* Snyder. Royal Silver Rainbow Trout.

Described from the deep waters of Lake Tahoe, the Royal Silver has always been rare, and now may be extinct.

5c. *Salmo gairdneri smaragdus* Snyder. Emerald Rainbow Trout.

Presumed to be the Pyramid Lake counterpart of the Royal Silver, this variety is also seemingly extinct. If, as supposed, it spawned in the lake, its loss must be attributed to other factors than those which killed off the river-spawning Lahontan Cutthroat (i.e., inability to leave the lake for the annual up-river spawning run due to low water and obstructions at the mouth of the river). It is more likely that the Emerald Rainbow was a river spawner also and died out for the same reasons as did the Lahontan Cutthroat. Those species which can spawn in lakes, such as the Lahontan Tui Chub, Lahontan Redside Shiner, three species of suckers and the introduced Sacramento Perch and Carp, still maintain themselves in Pyramid Lake in large numbers.

6. *Salvelinus fontinalis* (Mitchill). Eastern Brook Trout.**

An early importation into Nevada, planted widely, regularly and successfully. Its adaptation to cold waters makes it an admirable species for high mountain streams and lakes.

7. *Salvelinus malma* (Walbaum). Dolly Varden Trout.
Occurred, at least originally, in some of the upper Snake River tributaries in northeastern Nevada, and may have been planted sparingly in some northern sections of the State, but no reliable information is available at present.

8. *Salvelinus namaycush* (Walbaum).[2] Lake Trout.**
This large charr has long maintained itself successfully in Lake Tahoe, where it has never been very popular and where it has borne the brunt of blame for the reduction of the native cutthroat population. Probably mismanagement of spawning streams tributary to the lake has been a much more important factor in reducing the cutthroat than have been the presence and habits of the Lake Trout.

9. *Coregonus williamsoni* Girard. Mountain Whitefish.
Native to Lahontan basin waters and the area north of Nevada. A rather mediocre sport fish whose capabilities will be more-and-more appreciated by the ever-increasing angler in a land of declining fishing waters.

Family Catostomidae. The Sucker Family.

10. *Pantosteus lahontan* Rutter. Lahontan Mountain-sucker.
A small species native to the Lahontan drainage. Interestingly enough, it now occurs in some of the headwaters of the Feather River's North Fork, west of the Sierra Nevada crest, and now has theoretic access to the Sacramento drainage system (Rutter, 1908).

11. *Pantosteus intermedius* (Tanner). White River Mountain-sucker.
Described from a restricted locale in southeastern Nevada [Pahranagat Valley (Alamo), Lincoln County], and known only from the type locality.

12. *Catostomus tahoensis* Gill & Jordan. Tahoe Sucker.
The commonest and one of the largest of the Lahontan suckers, this species is one of the characteristic fishes of the Lahontan system, to which it is confined. Lacustrine specimens from Pyramid Lake grow to a length in excess of two feet, and of late years, breeding schools of smaller individuals (12") have been about the only fish capable of making spawning runs up the greatly curtailed Truckee River. Snyder's *C. arenarius*, the Sandbar Sucker, of Pyramid Lake, may not be distinct from *C. tahoensis*.
Kimsey (1950) has recently called attention to another instance of possible stream capture in which several typical Lahontan species may have been naturally diverted from the Lahontan system to the Sacramento system in the Lake Tahoe area. Similarly involved are the species *Richardsonius egregius* and *Rhinichthys nubilus robustus*.

13. *Catostomus latipinnis* Baird & Girard. Flannelmouth Sucker.
A member of the Colorado River system, formerly, at least, of some importance in the Indian fishing economy. Grows to a length of about two feet.

14. *Catostomus macrocheilus* Girard. Columbia Basin Sucker.
First recorded from the Snake River tributaries of northeastern Nevada by Miller and Miller (1948) (see *Oncorhynchus tshawytscha*). Partial to colder waters, and once a staple food for the Indians of the region.

15. *Catostomus columbianus* (Eigenmann & Eigenmann). Columbia River Sucker.
Only lately resurrected from the synonymy of *Pantosteus jordani* by Miller and Miller (1948), this species occurs with *C. macrocheilus*.

16. *Catostomus ardens* Jordan & Gilbert. Utah Sucker.
Recorded from the Nevada tributaries of the Bonneville system of Utah.

17. *Chasmistes cujus* Cope. Cui-ui Sucker.
Native to Pyramid Lake, habitually running up the lower Truckee River in large spawning schools in late spring-early summer. Formerly, at least, they ascended the river through moderately swift water to a point some 35 miles above the lake in spite of their relatively weak swimming powers. Interestingly enough, no one has ever been able to identfy young Cui-ui in either river or lake sucker populations, and the adults are evidently deep water inhabitants during all but the spawning season. For the past four years (1948-1951), they have been unable to enter the river because of insufficient inflow; fortunately for the species, which is a good food fish, taken by Indians and whites alike, they will spawn in the lake when unable to go up-river.

[2] Miller (1950) has reduced *Cristivomer* to subgeneric status.

18. *Xyrauchen texanus* (Abbott). Razorback Sucker.
A large, grotesque, hump-backed species native to the Colorado River system.

Family Cyprinidae. The Carp Family (Minnow, Chub, Dace, Shiner, etc.).

19. *Cyprinus carpio* Linné. Carp.**
Distributed in nearly every suitable water in Nevada, from the early days, and very abundant in most places. Among other places, Pyramid Lake is host to an immense population, some individuals of which exceed three feet in length.

20. *Carassius auratus* (Linné). Goldfish.**
This species has been turned loose in a few restricted areas of the State, and seems to maintain itself, although not abundantly.

21. *Orthodon microlepidotus* (Ayres). Sacramento Blackfish.** [3]
A specimen of this California species was identified by Dr. Robert R. Miller from material collected by the writers in a small pond on the outskirts of Reno. The pond contained "chub," Green Sunfish and Northern Black Bullheads, and during the winter of 1948-1949 the weather was severe enough to winter-kill everything except the catfish, which were safely buried in the mud. After examining the "chub," Dr. Miller wrote that one specimen was an *Orthodon* and the remainder were hybrids, presumably between *Orthodon* and *Siphateles bicolor obesus*. He offered the tentative suggestion that *Orthodon* may have gained access to the pond through fish rescue material sent up from the Sacramento Valley. At any rate, this is the only known instance of such an introduction, but the possibility exists that *Orthodon microlepidotus* is present in other parts of the Truckee Meadows surrounding Reno.

22. *Acrocheilus alutaceum* Agassiz & Pickering.[4] Chiselmouth.
A rather small member of the Columbia River fauna, associated with *Ptychocheilus oregonense*, *Catostomus macrocheilus* and *C. columbianus*.

23. *Ptychocheilus oregonense* (Richardson).[4] Columbia Squawfish.
A distinctive, pike-shaped member of the Columbia River system, being found in the Snake River tributaries of northeastern Nevada.

24. *Ptychocheilus lucius* Girard. Colorado River Squawfish.
This species occurred, at least originally, in considerable numbers in the Colorado River, and has the distinction of being the largest carp in the United States, attaining lengths up to five feet, and weights up to 80 pounds. Because of changes in those portions of the Colorado River adjoining Nevada, where the river has become a reservoir, the large squawfish has become a rarity.

25. *Gila robusta* Baird & Girard. Bonytail Chub.
25a. *Gila robusta robusta* Baird & Girard. Tributary Bonytail Chub.
25b. *Gila robusta elegans* Baird & Girard. Colorado River Bonytail Chub.
These two varieties impinge only on extreme southern Nevada, where *G. r. robusta* seems to be a form inhabiting smaller streams and tributaries of the Colorado River, while *G. r. elegans* is a highly streamlined swift-water species occurring in the main river channel. The so-called "Virgin River Bonytail Chub" (*G. r. seminuda* Cope & Yarrow) is probably best regarded as an intergrade between *robusta* and *elegans*.

26. *Gila jordani* Tanner. Nevada Bonytail Chub.
Recently described (1950) from Pahranagat Valley (Alamo), Lincoln County, and known only from the type locality, this chub is very close to *G. robusta*; it probably represents a segment of the original *G. robusta* population which has been isolated in the midportion of Pleistocene White River, at one time connected by a permanent flow of water to the Colorado River.

27. *Gila atraria* (Girard). Utah Chub.*
A member of the Bonneville Basin fauna of Utah and extreme eastern Nevada, this species has been planted in isolated waters around the periphery of its natural range in east-central Nevada, in several valleys without connection to the Bonneville drainage proper (Miller and Alcorn, 1945).

[3] This is the "Greaser Blackfish" of the official California list. We follow the official American Fisheries Society listing of "Sacramento Blackfish" as being preferable both by wider prior acceptance and by lacking some of the connotations of the California name.

[4] As pointed out by Miller in correspondence, *A. alutaceus* and *P. oregonensis* are orthographically incorrect, since both generic terms are neuter.

28. *Richardsonius egregius* (Girard). Lahontan Redside Shiner.

A common bait minnow native to the Lahontan system, occurring in great numbers in both streams and lakes, from the Sierra to the Nevada flatlands. Some individuals in spawning colors, as observed by the authors in the Reese River (central Nevada), may be as resplendent as any fish in the State.

29. *Richardsonius balteatus* (Richardson). Northern Redside Shiner.

29a. *Richardsonius balteatus hydrophlox* (Cope). Bonneville Redside Shiner.

This variety of the Northern Redside Shiner lives in the Snake River system above the falls, occurring in the Bonneville drainage and in the northeastern Nevada streams tributary to the Snake (see *Oncorhynchus tshawytscha*) (Miller and Miller, 1948).

29b. *Richardsonius balteatus::balteatus x hydrophlox.*

Among the material collected by Miller and Miller (1948) from the Snake River tributaries in northeastern Nevada were specimens which Dr. Robert R. Miller considers to be hybrids between the typical subspecies, *R. b. balteatus*, and the Bonneville subspecies, *R. b. hydrophlox.*

30. *Siphateles bicolor* (Girard). Tui Chub.

30a. *Siphateles bicolor obesus* (Girard). Lahontan Tui Chub.*

The very common and widespread chub of the Lahontan system, occurring in Pyramid Lake in large schools; occasionally completely isolated in small springs, such as the thriving population in Fish Springs, southeastern corner of Honey Lake Valley, Washoe County. Snyder's *Leucidius pectinifer*, described in 1918 from Pyramid Lake, has been reduced to a subspecies of *S. bicolor*, of which it is considered to be the lacustrine form (Hubbs and Miller, 1943). However, on the basis of recent data, we are convinced that *pectinifer* has no valid standing as a taxonomic unit. Genetically, *pectinifer* might be preserved to indicate tui chub with fine gill rakers (as Shapovalov and Dill, 1950, have done), just as it might be feasible, under some circumstances, to so distinguish between people with blue eyes and people with brown eyes. Chub with coarse gill rakers occur side-by-side with individuals with fine gill rakers, contrary to Snyder's supposition that he could observe them segregating in separate schools in the lake. Gill net sampling in Pyramid Lake by the writers has resulted in catches of chubs with both types of gill rakers at the same time and place, and there is no sexual correlation between raker differences. Whether there are any differences in feeding habits between the two types remain to be seen, but the above sampling, during the winter, showed both to be mixed in the same schools and to be feeding on the bottom on the same materials. It is possible that at other times of the year one form may have an advantage over the other in being able to obtain more plankton from the water, but at present, that is a dubious point.

31. *Rhinichthys nubilus* (Girard). Speckled Dace.

31a. *Rhinichthys nubilus nubilus* (Girard). Columbia Speckled Dace.

This variety occurs in the northeastern Nevada tributaries of the Columbia-Snake system.

31b. *Rhinichthys nubilus robustus* (Rutter). Lahontan Speckled Dace.

This is the subspecies common to the Lahontan system, widely disseminated. With *Richardsonius* and *Siphateles*, it constitutes the common bait minnow.

31c. *Rhinichthys nubilus nevadensis* Gilbert. Amargosa Speckled Dace.

Restricted to the Amargosa drainage system of southwestern Nevada and the adjacent Death Valley region of California.

31d. *Rhinichthys nubilus velifer* Gilbert. White River Speckled Dace.

Described originally from Pahranagat Valley (Alamo) in southeastern Nevada, and restricted to the relict White River system, which no longer has any continuity.

32. *Moapa coriacea* Hubbs & Miller. Moapa Dace.

An interesting relict warm water form, known only from the type locality (Warm Springs, Clark County), and but recently described (1948). Although Warm Springs is directly connected to the Colorado River, being the headwaters of the Moapa River, colder waters below the springs seem an effective barrier to the species, completely isolating it.

33. *Eremichthys acros* Hubbs & Miller. Soldier Meadows Dace.

Another endemic warm water species, known only from its type locality in southwestern Humboldt County, Nevada. Originally an affluent of Pleistocene Lake Lahontan, the springs and stream of Soldier Meadows now lie several

hundred feet above Lahontan valley floors, completely isolated from neighboring streams. Associated with *E. aeros* are remnant populations of *Rhinichthys nubilus robustus* and *Catostomus tahoensis*, while farther down the same stream, in colder water, *E. aeros* disappears and the shiner *Richardsonius egregius* and the chub *Siphateles bicolor obesus* occur with *Rhinichthys* and *Catostomus*.

34. *Lepidomeda vittata* Cope. White River Spinedace.
This seldom reported dace has been listed by Gilbert (1893) from Pahranagat Valley (Alamo), Lincoln County, and this record has been much cited by later authors. Tanner (1936) discussed it from southwestern Utah.

35. *Plagopterus argentissimus* Cope. Woundfin.
Known from the Virgin River, Clark County.

Family Ameiuridae. The Catfish Family.**

36. *Ictalurus lacustris* (Walbaum). Channel Catfish.**
36a. *Ictalurus lacustris punctatus* (Rafinesque). Southern Channel Catfish.**
Planted in the Colorado River, and now common in the lower reaches of the river.

37. *Ictalurus catus* (Linné). White Catfish.**
Has been established in the vicinity of Fallon, Churchill County, but does not seem to be particularly successful (Miller and Alcorn, 1945).

38. *Ameiurus nebulosus* (Le Sueur). Brown Bullhead.**
38a. *Ameiurus nebulosus nebulosus* (Le Sueur). Northern Brown Bullhead.**
One of the earliest introductions into the State, and now a very common game fish in the Lahontan drainage. Miller and Alcorn (1945) also recorded it from Pahranagat Valley (Alamo), Lincoln County.

39. *Ameiurus melas* (Rafinesque). Black Bullhead.**
39a. *Ameiurus melas melas* (Rafinesque). Northern Black Bullhead.**
Known from various parts of the Lahontan system, associated with *A. nebulosus*. Introduced into the Reese River in 1942 (Miller and Alcorn, 1945).
39b. *Ameiurus melas catulus* (Girard). Southern Black Bullhead.**
Miller and Alcorn (1945) recorded this form from near Las Vegas, Clark County. No other records of its occurrence in the State have been seen.

Family Cyprinodontidae. The Killifish Family.

40. *Crenichthys baileyi* (Gilbert). White River Springfish.
A small thermal species confined to the remnants of Pleistocene White River in southeastern Nevada.

41. *Crenichthys nevadae* Hubbs. Railroad Valley Springfish.
The counterpart of *C. baileyi* immediately to the west.

42. *Empetrichthys merriami* Gilbert. Ash Meadows Springfish.
Confined to Ash Meadows, Nye County, a portion of the Armagosa drainage system of southwestern Nevada-southeastern California.

43. *Empetrichthys latos* Miller. Pahrump Springfish.
43a. *Empetrichthys latos latos* Miller. (Manse Ranch.)
43b. *Empetrichthys latos pahrump* Miller. (Pahrump Ranch.)
43c. *Empetrichthys latos concavus* Miller. (Raycraft Ranch.)
The species occurs only in Pahrump Valley, Nye and Clark Counties; while it is just a matter of a few miles distant from Ash Meadows, *E. latos* is effectively isolated from the adjacent population of *E. merriami* and has been, evidently, for some time.

44. *Cyprinodon nevadensis* Eigenmann & Eigenmann. Amargosa Pupfish.*[5]
44a. *Cyprinodon nevadensis mionectes* Miller. Ash Meadows Amargosa Pupfish.
44b. *Cyprinodon nevadensis pectoralis* Miller. Ash Meadows Amargosa Pupfish.
This small species, native to the Amargosa drainage originating in southwestern Nevada and terminating in Death Valley, California, seldom exceeds two inches in length and, like most of our cyprinodonts, is a warm water type.

[5] This is the "Nevada Pupfish" of the official California list. We prefer "Amargosa Pupfish" as the more geographically suitable term.

Robert R. Miller has subdivided the Amargosa region population into five subspecies, of which only the above two Ash Meadows (Nye County) varieties belong on the Nevada list.

Miller and Alcorn (1945) have recorded an instance of the probable introduction of the species into the Las Vegas area which, while not too distant from the Amargosa basin is, nevertheless, in a different drainage system.

45. *Cyprinodon diabolis* Wales 1930. Devil Pupfish.*

This tiny species, the smallest of the genus, lives only in the limestone pothole, Devil's Hole, in Ash Meadows, Nye County, where the waters maintain a constant temperature of approximately 33°C. (92°F.). In the winter of 1946-47, the writers transferred some 75 specimens to a nearby warm spring connected with the principal drainages of the valley (La Rivers, 1950b), in an effort to provide some sanctuary for the unique species in the not then remote contingency that tampering with the waters of Devil's Hole by local interests would result in extermination of the species. Since *C. diabolis* was in contact with *C. nevadensis* in the new location, there is always the possibility of failure to establish by reason of hybridization. No data are yet available concerning the outcome of the experiment, but cooperative plans are underway by the Nevada Fish and Game Commission and the University of Nevada to plant the species in one of several suitable warm water springs in west-central Nevada.

Family Poeciliidae. The Top-minnow Family.**

46. *Gambusia affinis* (Baird & Girard). Mosquitofish.**

46a. *Gambusia affinis affinis* (Baird & Girard). Western Mosquitofish.**

Widespread throughout the State in all suitable waters, warm and cold. Some of the largest specimens seen were from the cold waters of the Virgin River in extreme southern Nevada. In warm, near-stagnant waters such as Wally Hot Springs (Genoa), Douglas County, they can become extremely abundant and are then usually much infected with fungus and other diseases.

Family Percidae. The Perch Family.**

47. *Perca flavescens* (Mitchill). Yellow Perch.**

Has been established in restricted areas in west-central Nevada.

Family Centrarchidae. The Sunfish Family.**

48. *Micropterus dolomieu* Lacépède. Smallmouth Black Bass.** [6]

48a. *Micropterus dolomieu dolomieu* Lacépède. Northern Smallmouth Black Bass.**

There have been several known introductions of this black bass into Nevada, some from the early days, but according to Miller and Alcorn (1945), most of these were unsuccessful, and the species seems to be well established only in Lake Mead in southern Nevada.

49. *Micropterus salmoides* (Lacépède). Largemouth Black Bass.**

An early importation, the largemouth is common to suitable waters over the State from Lake Mead to the Ruby Marshes and west-central Nevada. The Ruby Marsh locality, first planted in the early 1930's (Trelease, 1948), became for a time an excellent black bass water, but no forage fish were planted with the black bass and overpopulation soon reduced their unit size. During the severe winter of 1948-1949, winter kill nearly eliminated the fish population, giving the needed opportunity to introduce forage fish, the outcome of which is not yet evident.

50. *Lepomis cyanellus* Rafinesque. Green Sunfish.**

Miller and Alcorn (1945) could list but one instance of the importation of this species into the State, but the Green Sunfish is rather widely distributed in west-central and southern Nevada. In the Truckee Meadows (Reno) region, the species is common in many ponds, where it is often mistaken for Bluegill.

[6] We suggest the collective term "blackbass" for the same reasons "sunfish, pupfish, whitefish, catfish, blackfish," etc., are in general usage. The word "bass" has been used so loosely as to have little definitive meaning as such.

51. *Lepomis macrochirus* Rafinesque. Bluegill.**
    51a. *Lepomis macrochirus macrochirus* Rafinesque. Common Bluegill.**
    This animal has been planted in various parts of Nevada, on several different occasions, but seems common now only in Lake Mead, Clark County.

52. *Archoplites interruptus* (Girard). Sacramento Perch.**
    This species shares honors with the bullheads as one of the earliest game fish introductions. For a good many years it has supported a substantial sport fishery in Walker Lake, Mineral County. It also occurs in most suitable ponds and reservoirs in west-central Nevada, as well as in Pyramid Lake; lack of fishing in the latter since the decline there of the Cutthroat Trout makes the status of the Sacramento Perch as a game fish unknown at present.

53. *Pomoxis annularis* Rafinesque. White Crappie.**
    At this writing (1951), there is but one known importation of this species: 200 two-and-a-half inch fish from a Georgia hatchery were planted in Fish Creek Springs, 25 miles south of Eureka, Eureka County, in March of 1950, and it is somewhat early to judge the effectiveness of the experiment.

54. *Pomoxis nigromaculatus* (Le Sueur). Black Crappie.**
    Several implantations of Black Crappie have been made in west-central and southern Nevada in the last 25 years, but the species appears to be common, at the present time, only in Lake Mead, Clark County.

Family Cottidae. The Sculpin Family

55. *Cottus bairdi* Girard. Mottled Sculpin.
    55a. *Cottus bairdi beldingi* Eigenmann & Eigenmann.[7] Smooth Mottled Sculpin.
    A characteristic native of the upper, cooler reaches of all major streams of the Lahontan system, as well as areas to the north of Nevada.

SUPPLEMENTARY LIST

Exotic Species—Unsuccessfully Introduced

The following list is concerned with those species which have been unsuccessfully planted in the State. Miller and Alcorn (1945) have previously summarized most of these data.

Family Salmonidae. The Salmon and Trout Family.

1. *Oncorhynchus keta* (Walbaum). Chum Salmon.**
    Widely planted in west-central Nevada in 1939, but none are known to have survived (as would be expected).

2. *Oncorhynchus kisutch* (Walbaum). Silver Salmon.**
    Planted in the Carson and Truckee rivers in 1913.

3. *Oncorhynchus nerka* (Walbaum). Red Salmon.**
    3a. *Oncorhynchus nerka nerka* (Walbaum).**
    According to the Nevada Fish and Game Commission Biennial Reports for the years 1936, 1938 and 1941, several attempts, evidently unsuccessful, were made to establish "*Oncorhynchus nerka*," the "Sockeye Salmon," in west-central Nevada. It is presumed that these were the anadromous form.

4. *Salmo salar* Linné. Atlantic Salmon.**
    4a. *Salmo salar sebago* Girard. Landlocked Atlantic Salmon.**
    An early introduction into Lake Tahoe and the Carson and Truckee rivers (1880's), where they were reported a temporary source of good fishing.

5. *Salmo clarki* Richardson. Cutthroat Trout.**
    5a. *Salmo clarki stomias* Cope. Greenback Cutthroat Trout.**
    Planted in 1892-1893 in the Humboldt River near Elko, presumably from a Federal hatchery in Colorado. If any of the strain survived, mixture with other subspecies of cutthroats soon obliterated its characteristics.

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[7] This has long been considered the species *C. beldingi*, and is still so regarded by some taxonomists. We are used to using the name specifically, but since the group is a plastic one whose entities are difficult to separate, the differences in treatment do not seem important.

6. *Salmo gairdneri* Richardson. Rainbow Trout.**
  6a. *Salmo gairdneri gairdneri* Richardson. Northcoast Rainbow Trout.**[8]
  Presumably brought into the State in the early 1900's, as "steelhead" trout, but unknown here at the present time.

7. *Salmo aguabonita* Jordan. Golden Trout.**
  1918-1919 plants were made in the Lake Tahoe region, but no survivals are known.

8. *Coregonus clupeaformis* (Mitchill). Lake Whitefish.**
  8a. *Coregonus clupeaformis clupeaformis* (Mitchill). Great Lakes Whitefish.**
  First brought into Lake Tahoe in the 1870's from Lake Michigan spawn, and later introduced into the Eureka area of central Nevada.

Family Thymallidae. The Grayling Family.**

9. *Thymallus signifer* (Richardson). Arctic Grayling.**
  9a. *Thymallus signifer tricolor* Cope. American Arctic Grayling.**
  Introduced into Ruby Valley, Elko County, within the past ten years, and probably previously into the Lake Tahoe region. The junior author planted some 500 fingerlings in Kings Canyon near Carson City, Ormsby County, in 1948, but none are known to have survived.

Family Clupeidae. The Herring Family.**

10. *Alosa sapidissima* (Wilson). American Shad.**
  An early plant made in the mid-1880's in the Colorado River near Nevada was not successful.

Family Cyprinidae. The Carp Family.**

11. *Tinca tinca* (Linné). Tench.**
  A shipment was sent to a Virginia City (Storey County) applicant in 1885.

REFERENCES

American Fisheries Society.
1948. A list of common and scientific names of the better known fishes of the United States and Canada. Amer. Fish. Soc., Special Publ. no. 1, 45 p.

Cope, Edward D., and H. C. Yarrow.
1875. Report upon the collections of fishes made in portions of Nevada, Utah, California, Colorado, New Mexico, and Arizona, during the years 1871, 1872, 1873, and 1874. U. S. Army Eng. Dept., Rept. Geog. and Geol. Explor. and Surv. West of 100th Merid., vol. 5, Zoology, chapt. 6, p. 635-700.

Curtis, Brian, and Jack C. Fraser.
1948. Kokanee in California. Calif. Fish and Game, vol. 34, no. 3, p. 111-114.

Fraser, J. C., and A. F. Pollitt.
1951. The introduction of kokanee red salmon (*Oncorhynchus nerka kennerlyi*) into Lake Tahoe, California and Nevada. Calif. Fish and Game, vol. 37, no. 2, p. 125-127.

Gilbert, Charles H.
1893. Report on the fishes of the Death Valley Expedition collected in southern California and Nevada in 1891, with descriptions of new species. U. S. Dept. Agric., North Amer. Fauna, no. 7, p. 229-234.

Hubbs, Carl L.
1932. Studies of the fishes of the order Cyprinodontes. XII. A new genus related to *Empetrichthys*. Univ. Mich. Mus. Zool., Occas. Paper no. 252, 5 p.

Hubbs, Carl L., and Robert R. Miller
1943. Mass hybridization between two genera of cyprinid fishes in the Mohave Desert, California. Mich. Acad. Sci. Arts and Let., Papers, vol. 28, p. 343-378.
1948. Two new, relict genera of cyprinid fishes from Nevada. Univ. Mich. Mus. Zool., Occas. Paper no. 507, 30 p.

[8] This is the "steelhead rainbow trout" of the official California list.

Jordan, David Starr, Barton Warren Evermann and Howard Walton Clark.
1930. Check list of the fishes and fishlike vertebrates of north and middle America north of the northern boundary of Venezuela and Colombia. U. S. Comm. Fish., Rept. for 1928, pt. 2, 670 p.

Kimsey, J. B.
1950. Some Lahontan fishes in the Sacramento River drainage, California. Calif. Fish and Game, vol. 36, no. 4, p. 438.

Kopec, John A.
1949. Ecology, breeding habits and young stages of *Crenichthys baileyi*, a cyprinodont fish of Nevada. Copeia no. 1, p. 56-61.

La Rivers, Ira.
1950a. The meeting point of Ambrysus and Pelocoris in Nevada (Hemiptera; Naucoridae). Pan-Pac. Ent., vol. 26, no. 1, p. 19-21.
1950b. The Dryopoidea known or expected to occur in the Nevada area (Coleoptera). Wasmann Journ. Biol., vol. 8, no. 1, p. 97-111.
1950c. A new naucorid genus and species from Nevada (Hemiptera). Ent. Soc. Amer., Ann., vol. 43, no. 3, p. 368-373.

Miller, Robert R.
1946a. Correlation between fish distribution and Pleistocene hydrography in eastern California and southwestern Nevada, with a map of the Pleistocene waters. Journ. Geol., vol. 54, no. 1, p. 43-53.
1946b. *Gila cypha*, a remarkable new species of cyprinid fish from the Colorado River in Grand Canyon, Arizona. Wash. Acad. Sci., Journ., vol. 36, no. 12, p. 409-415.
1948. The cyprinodont fishes of the Death Valley system of eastern California and southwestern Nevada. Univ. Mich. Mus. Zool., Misc. Publ. no. 68, p. 1-155.
1950. Notes on the cutthroat and rainbow trouts with the description of a new species from the Gila River, New Mexico. Univ. Mich. Mus. Zool., Occas. Paper no. 529, p. 1-42.

Miller, Robert R., and J. R. Alcorn.
1945. The introduced fishes of Nevada, with a history of their introduction. Amer. Fish. Soc., Trans., vol. 73, p. 173-193.

Miller, Robert R., and Ralph G. Miller.
1948. The contribution of the Columbia River system to the fish fauna of Nevada: five species unrecorded from the State. Copeia no. 3, p. 174-187.

Nevada State Fish and Game Commission.
1936. Biennial Report for the fiscal years 1934-1936, p. 1-14.
1938. Biennial Report for the fiscal years 1936-1938, p. 1-17.
1941. Biennial Report for the fiscal years 1938-1940, p. 1-16.

Rutter, Cloudsley.
1904. Notes on fishes from streams and lakes of northeastern California not tributary to the Sacramento basin. U. S. Fish Comm., Bull. for 1902, vol. 22, p. 145-148.
1908. The fishes of the Sacramento-San Joaquin basin, with a study of their distribution and variation. U. S. Bur. Fish., Bull. 1907, vol. 27, p. 105-152.

Shapovalov, Leo.
1940. The fresh-water fish fauna of California. Sixth Pac. Sci. Cong., Proc., vol. 3, p. 441-446.

Shapovalov, Leo, and William A. Dill.
1950. A check list of the fresh-water and anadromous fishes of California. Calif. Fish and Game, vol. 36, no. 4, p. 382-391.

Snyder, John Otterbein.
1914. A new species of trout from Lake Tahoe. U. S. Bur. Fish., Bull., 1912, vol. 32, p. 25-28.
1918. The fishes of the Lahontan system of Nevada and northeastern California. U. S. Bur. Fish., Bull., 1915-1916, vol. 35, p. 33-86.
1921. Notes on some western fluvial fishes described by Charles Girard in 1856. U. S. Nat. Mus., Proc., vol. 59, p. 23-28.

Sumner, Francis H.
1940. The decline of the Pyramid Lake fishery. Amer. Fish. Soc., Trans., vol. 69, p. 216-224.

Tanner, Vasco M.
1936. A study of the fishes of Utah. Utah Acad. Sci., Arts and Let., vol. 13, p. 155-184.
1942. A review of the genus Notolepidomyzon with a description of a new species (Pisces—Catostomidae). Great Basin Nat., vol. 3, no. 2, p. 27-32.
1950. A new species of Gila from Nevada (Cyprinidae). Great Basin Nat., vol. 10, nos. 1-4, p. 31-36.

Trelease, Thomas Jarvis.
1948. Report of field survey and investigation of the fisheries resources of Ruby Lakes, Nevada. Nevada Fish and Game Comm., Mimeog. Rept., 10 p.
1949. What lies ahead for Pyramid Lake? Nevada Hunting and Fishing, vol. 1, no. 2, p. 8-10.

Wales, Joseph H.
1930. Biometrical studies of some races of cyprinodont fishes, from the Death Valley region, with description of *Cyprinodon diabolis*, n. sp. Copeia no. 3, p. 61-70.

RECENT CHANGES IN PURSE SEINE GEAR IN CALIFORNIA[1]

By ANITA E. DAUGHERTY
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The following notes are based on personal observation in the San Pedro region from October, 1942, onward, and from information supplied by fishermen and others connected with the industry. It is an attempt to put on record the most important changes in seine fishing gear or seiner equipment in the last 10 or 15 years, or in a few cases even older changes. The date of first use of each of these features, its rate of spread, and its present status in the fishery is given as far as these facts are known. There is possibility of error in some of this information, for example in dates and boat names, but I do not think any of the facts are too far from the truth, and it seems desirable to get them in print. "At present" as used in the text means the spring of 1951.

BOAT AND NET TYPES

Boats built within about the last seven years have tended to be of two types, both perhaps a response to scarcity of sardines or to limited cannery demand in some seasons. One type has been the "baby purse seiner," around 50 feet in length, using a net of typical purse seine construction and handled exactly as is the larger purse seine except that there is no turntable. A boat like this, representing a smaller investment and with only about eight crew members, can operate profitably when fishing is not too good or cannery limits are low, and may even share out better than the larger boats. The NYNA ROSE, 47 feet registered length, is typical of these boats; it was built in the summer of 1944, and was one of the first of the new group of such boats fishing in the Los Angeles region.

During approximately the same time interval, a number of very large seiners, 80 feet and over in registered length, have been built for fishing tuna part or all of the year. Their large size and brine tanks equip them for going farther afield and making longer trips.

In the early 1940's, to about 1947, there were approximately 20 seiners in the Los Angeles region using ringnets (often loosely referred to in Southern California as a "lampara" or "half-ring"). These were fair-sized boats, 62 to 72 feet in registered length. The net was an evolutionary development of the lampara, much increased in size, with purse rings the length of the net, and hung nearly straight but retaining the bag location in the middle of the net. It had the advantage of being a somewhat lighter weight and less expensive net, and of being worked more rapidly than a purse seine. It had the disadvantage of requiring a larger crew, of involving more back-breaking work, and of not being workable under

[1] Submitted for publication May, 1951.

as great a variety of weather conditions. One by one, these boats began changing to purse seine nets for the summer tuna fishing, followed the next sardine season, or two or three seasons later, by purse seine nets for sardine fishing. In the 1949-50 season, there were only nine of these nets left; in 1950-51, only five.

NET PRESERVATION

In San Pedro, initial tarring of the net, followed by weekly or bimonthly treatment with bluestone (copper sulphate) and salt, has become the principal method of treatment for sardine nets. For tuna nets, in southern waters, tarring is followed by simply washing in salt water. Tanning is used very little at present. The five seasons 1942-43 through 1946-47, for example, saw the complete or almost complete shift of the approximately 20 ringnet boats from tanning to tarring. This is a reversal of the trend reported by Tibby (1936) who at that time reported a growing shift from tarring to tanning.

In Monterey, nets are tarred initially, but subsequent treatment in many cases still consists of tanning rather than bluestoning.

Several types of tar are used. One is a coal-tar mixed with creosote, which is used cold. Another, used by most, is Seattle tar mixed with creosote, which is used hot; it is comparatively quick drying. Another is pine tar, used hot; it takes 50 days or more to dry, but is used by some because they believe it leaves the net softer.

Several brands of copper net-dipping preparations have been tried. While these have been used for some time on shark nets and others in the north, the first I saw on a seine net was in April, 1947, on the YANKEE CLIPPER. This type of preservative completely replaces tar and other preservatives, when used. Some boats have found it satisfactory but most have not.

CORKS

Formerly, the top of the net was floated almost entirely by real (Spanish or Portuguese) corks, plus a few large rubber floats. Increase in price of corks during World War II led to other types of floats being tried. Rubber and plastic floats, of about the same size and shape as the cork, were used, but neither of them very extensively. More popular has been the "black cork," made of a tar and carbon mixture, first manufactured for use on life rafts during the war. These, while much more brittle and apt to chip than cork, are still fairly durable. At present, some nets use all cork, others use combinations of cork with carbon, often placing the former at the ends of each group to provide padding: say, one or two cork, eight or nine carbon, and one or two cork; two cork, four carbon, and two cork; or some other such combination. In July, 1947, the carbon floats were selling for 6 or 7 cents apiece as compared with about 35 cents for cork. At present, the carbon floats have become scarce (and it is believed will be unavailable in the future) and are selling for 12 cents, while corks cost from 25 to 35 cents.

Newest are football-shaped floats of hard red sponge rubber, first used by the LIBERATOR, BETSY ROSS, SEA ROVER, and several other boats on their tuna nets in the spring of 1951. These are said to be very durable and to have four times the buoyancy of Spanish corks and six or seven times that of the black corks. They are expensive, however, selling for $1.10 apiece, and their relative value has yet to be proven.

CORK PURSE LINE

Tibby (1936) records the cork purse line as originating in about 1933, and predicts its eventual spread to the rest of the purse seines. This has come about; all now have it. It consists of small rings along the corkline, one about every two to four fathoms in a sardine net, and two to three fathoms in a tuna net. Through these a series of ropes is strung. For the first few years, the rings were strung during each set; since perhaps 1938, the ropes, now a series of about 10 in number on a sardine net and 12 to 15 on a tuna net, are a permanent part of the net. Before the pursing of the bottom of the net has been completed, pursing of the corkline has been begun, bunching the corks up so that the corkline can be attached to the skiff, thus keeping it from being pulled under by the fish and also keeping the net where it is less likely to drift under the boat. On a sardine net, about four groups of corks are bunched up with the use of a power niggerhead in the bow, four more from the skiff (with the aid of the skiff niggerhead if there is one), and two more from the stern, which may be done on a tiny niggerhead on the stern but much more often by hand-pulling or by making use of the niggerhead on the main winch.

STEEL CABLE PURSE LINES

The first use of steel cable as a purse line was by Jack Berntsen on the MABEL, in 1927. He had seen it used while visiting in Norway. This was followed by the YUKON in about 1928. Then three or four of the large boats tried it but did not know how to use it correctly, and abandoned it. Later, the skipper of an Alaska herring boat learned from Berntsen how to use it, and put it on his boat in about 1931-1932. This was successful and spread in the North, and eventually worked back into California. Within the last 10 years, galvanized steel cable has come to replace rope for purse lines on almost all seiners, at least those 60 feet and longer. It has the advantage of being stronger than rope. Also, it can be braked as it goes off the drum, making it possible to set the net at an angle in the water, with the leadline considerably shorter than the corkline. This is desirable when fish are likely to sound and try to go under the net (particularly with tuna), or when the net is set in shallow water, in which case it reduces its tendency to roll.

CHAIN LEADLINES

The first skipper to use steel chain in place of leads strung on a rope was Joe Vilicich on the MARAUDER, who put it on his sardine net in the fall of 1946. The COURAGEOUS put one on shortly afterwards, and the GOLDEN WEST was third. Both the MARAUDER and the GOLDEN WEST also had chain bridles. The VASHON and WESTERN FISHER put chain leadlines on their tuna nets in the spring of 1947, and one or two other boats may have had them by the following September. As the greater strength and longer life of the chain became apparent, as well as the greater ease in hanging a net with it, other fishermen began changing. The greater initial cost, and particularly the fact that the fishermen already have leads on hand, has caused a little delay in the fleet's changing over, but present indications are that within several years most of the boats will have chain leadlines. At present, some have chain bridles and some retain rope.

THE "STICK"

Some sort of pole or outrigger, used to hold the skiff away from the boat and the net open during a set, has been used for many years by seiners. However, in its present form, permanently attached by a hinge, it was first used by Marion Spanjol, fishing on the WANDERER at San Francisco in the 1932-33 sardine season, and immediately after that by Pete Dragich on the SEA RANGER. It proved its usefulness so quickly that the next season almost every boat was using one. The stick consists usually of a long peeled trunk of eucalyptus or some other tree, carried lashed against the rigging on the port side of the boat; it is permanently attached at the bottom, but moves on this attachment so that it can be lowered. It may be brought into use early in a set, as soon as the corks are bunched; or not until just before brailing. In either case, the skiff lies on the opposite side of the net from the boat, with the bunched-up sections of corkline tied along its side. The stick is lowered so that it lies across the skiff, with the end projecting on the far side; it is lashed loosely to it. This not only reduces the chance of the corkline being pulled under and the skiff perhaps turned over if the fish should sound, but it helps keep the skiff at a fixed distance from the boat and the bag open so the fish are not crowded.

In sardine or mackerel fishing, the stick is used by some seiners for catches of 20 tons and up, but by most not until they have much more (unless they are working in rough weather). The news, broadcast over the radio, that a boat in set was seen with its stick out, is taken as an indication that it had a pretty good catch. In tuna fishing, the stick may be used by one fisherman for all sets, by others for catches of 20 to 40 tons and up; in general, it is used for much smaller amounts than in sardine or mackerel fishing.

THE ZIPPER

The zipper is a device consisting of a vertical series of galvanized steel rings extending the depth of a purse seine net, in the center, with a rope running through them. This facilitates what is known as "making a cut," that is, dividing the net into two parts or "bags" when a large school of sardines or mackerel has been surrounded. Zippers are believed to have been first used at Monterey; in the San Pedro region, the COSTA RICA II was one of the first to use it, in 1931. Almost all sardine nets now have a zipper.

Only a small minority of tuna nets are so equipped. The greater strain placed on the net by a school of tuna often makes it desirable to make many cuts, at intervals along the net. Each of these is made by picking up the meshes by hand, in as straight a vertical line as possible. Cuts may be made in handling even a small school of tuna. One seiner, the GOLDEN WEST, has three bag areas of heavier twine and smaller mesh in its tuna net, and marks the location for making cuts by hand with white string. Another, the DEFIANCE, has five bag areas of new webbing, similarly marked. Where a tuna net does have a zipper (or rarely two of them), it is often with the idea of using it quickly, to pen off porpoise from the main body of the tuna school.

DRAGGER WINCHES

A number of boats, in the last few years, have installed Northern Dragger, Northern Seiner, or other double drum trawl-type winches. The first of the California fleet to have this type of winch was the FISHER LASSIE, launched in July of 1944; this boat was also used part time for dragging. It was followed by the NORTH AMERICAN; MARAUDER (observed 1945-46 sardine season); RIO DEL MAR (observed 1946-47 sardine season); and gradually by other boats.

While much more expensive than the older type of winch, this type requires much less physical effort on the part of the winchman, and winds up and holds the purse cable, thereby eliminating drums in other places. Also, it is claimed that there is a saving on cable, as there is less strain and less tendency to kink than when the cable has to be wound around the niggerhead in bringing it in.

On the other hand, it is claimed that the winchman is more aware of any undue strain when using the older type winch, which may indicate, for example, that the net is caught and apt to rip.

BRINE TANKS

The seiners which go south for tuna have for some years been installing freezing coils in their holds at the start of the tuna season and (in most cases at least) taking them out again at the start of the sardine season. They also take crushed ice in the hold; the freezing coils help keep this from melting and crystallizing, and thus make possible longer trips. The fish when caught have to be stowed in bins in the hold, with alternate layers of fish and crushed ice. This is a hard and time-consuming job, particularly when following the many hours which a large tuna haul may take. Now, the larger seiners are all being built with brine tanks, and in many cases tanks are being installed in older boats. Most have from two to six tanks, in addition to a central hold area with freezing coils. A very few large all-year tuna boats have brine tanks only, and in that case may have as many as 8 or 10. Capacity runs from about 10 to 20 tons of fish per tank, and varies with the size of fish as well as size of tank. The first record I have of brine tanks on purse seiners is on two boats built in 1944, the RONNIE M and DELORES M with two tanks each. The SPARTAN (Fish and Game No. 5240) was all-brine sometime before August, 1945.

The brine tanks make stowage of the fish much easier and more rapid, and make it possible to keep them longer and in better condition. The tanks may be used to carry water or fuel during the earlier part of a trip. In sardine season, they may be used to hold overlimit fish for a day or so, or to hold over a small catch when a boat is fishing far from port. They may be filled with water to bring down the stern in order to make the boat ride better under certain conditions.

DEPTH SOUNDERS

One of the most rapid developments in seine fishing in recent years, and undoubtedly the most important, has been the introduction of depth-sounding equipment. The Fathometer, manufactured by Submarine Signal Company, was first used on a fishing boat on the east coast in 1929, on the west coast in 1932. Both the boats, I believe, were trawlers, although some of the tuna bait boats, beginning with the CHICKEN OF THE SEA, also had them in the early 1930's. The first installations on California seiners were made on the RONNIE M and the GENERAL MACARTHUR, in or by the fall of 1944. By December, 1945, at least 12 more seiners had them. Within two or three years after that, it could probably be said that every seiner in the fleet (except possibly a few of the small ones) had some kind of a depth-sounder; that is certainly the case at present.

Depth-sounders have proven valuable for general navigation purposes, adding to the safety of the vessels while traveling in fog or in strange waters; have enabled boats to scout for fish on foggy nights which might otherwise have kept them tied up or have prevented them from working close to shore; and have been particularly valuable in locating fish. They are used both in locating schools of fish which would not be seen at all, and in giving additional evidence as to the extent, depth, and thickness of schools which are located by sight. Some boats keep their depth-sounders running constantly while they are on possible fishing grounds; others turn them on only when a school is spotted or when a near-by boat makes a set. The most common type is one such as the Fathometer which has a flashing red light. A few boats have recording depth-sounders, such as the Bendix Depth Recorder.

RADAR

Three seiners have radar sets at present: the MARSHA ANN, STRANGER, and ANTHONY M. There does not seem to be any great interest in radar on the part of most of the fleet operators, due chiefly to the high cost. Prices for new sets installed are about $6,000 for a small set (with a 20-mile range) and $10,500 for a larger one.

RADIO-TELEPHONES

Radio sending and receiving sets for talking with other boats have been used in the Seattle region on seiners since 1933 or before. They must have been introduced in Monterey about the same time or shortly afterwards, as the first trial ship-to-shore communication was made there from the WESTERN MAID in 1934. In the San Pedro region, the first was installed by Steve Gargas on the COSTA RICA II in 1935 or 1936, followed very shortly by the BLUE SKY, LIBERTY BELL, VAGABOND, SPARTAN (Fish and Game No. 1296), ARKANSAS, and a number of others. Ship-to-shore communication was available immediately, having already been used by other types of vessels.

MOTOR SKIFFS

The first seiners to have skiffs with motors in them were the BONNIE M and the DELORES M, in 1944; they were followed shortly by the PRIDE OF AMERICA, which had used a motor boat as supplement to its skiff during the previous season's fishing, and in 1945 by the CITY OF LOS ANGELES.

By July, 1947, at least 13 more boats had motor skiffs. By the winter of 1949-50, they were observed on at least 35 of the 165 boats delivering sardines or tuna in the Hueneme or Los Angeles regions; this figure probably includes most of the California seiners having this feature. In the winter of 1950-51, motor skiffs were observed on at least 46 of the 232 seiners delivering sardines in the Hueneme or Los Angeles regions (out of 239 seiners fishing in the entire State), and in addition were probably present on all of the 12 seiners delivering tuna only. All the above figures refer only to the larger seiners, 60 feet and up in length. The extra skiff size and weight involved would probably make a motor skiff impractical on boats smaller than this; the smallest boat I have seen using one is a boat 62 feet in registered length.

The motor skiff is extremely useful in many ways. It is used to get to the open area opposite the tow line and patrol back and forth to keep the fish from getting out until the gap can be closed. This would occur when a very big circle has been made to get around a school of fish, and is particularly apt to happen when fishing tuna. It is used to get around the net more quickly when bunching up the corks (a small niggerhead installed in the skiff and run from the motor assists in this). It is used as a tug in moving the seiner when in set—when heading the wrong direction in relation to the swells, drifting over the net, drifting on the beach, or in the many other emergencies which may arise. It is used to keep two boats apart when one is giving fish to the other. It is used in taking men ashore when the boat has to anchor a distance off. In many such ways, it more than justifies its expense—about $3,800 for a small motor skiff up to $5,000 or $6,000 for a large one, at present—and this is particularly true when something goes wrong in a set.

At least two all-year tuna seiners, at present, carry small boats with inboard motors in addition to the big motor skiffs. The DEFIANCE uses one in place of the customary second small nonpowered skiff; the COLUMBIA uses both.

REFERENCE

Tibby, Richard S.
1936. The construction of the purse seine as used in the San Pedro sardine fishery, 1935-1936 season. Calif. Fish and Game, vol. 22, no. 4, p. 310-313.

NOTES

THE 1951 SHARK DERBY AT ELKHORN SLOUGH, CALIFORNIA

On May 20, 1951, soon after the starting hour of 7 a.m., 237 fishermen had registered at the Moss Landing Committee stand for the Elkhorn Slough Shark Derby. This annual event is sponsored by the Pajaro Valley Rod and Gun Club of Watsonville. By the 1 o'clock closing time 61 specimens representing three species of sharks and rays had been brought to the judging stand. They were as follows:

	Males	Females	Total	Percent catch	Largest specimen		
					Sex	Weight	Length
Leopard Shark, *Triakis semifasciata*	7	7	14	23.0	♀	24 lbs.	134 cm.
Shovelnose Guitarfish, *Rhinobatos productus*	4	14	18	29.5	♀	27 lbs.	130.5 cm.
Bat Stingray, *Holorhinus californicus*	8	21	29	47.5	--	85 lbs.	--

These catch records are most interesting when one considers the entire absence of such common Central California sharks as the dogfish (*Squalus acanthias*) and the brown smoothhound (*Triakis henlei*). Despite the fact that the brown smoothhound usually forms more than 50 percent of the San Francisco Bay shark population, here at Elkhorn Slough, which is approximately 120 shoreline miles southward, they were not present, at least insofar as the 1951 derby catches are concerned. The gray smoothhound (*Mustelus californicus*) is common in Southern California and is known from Morro Bay (Hubbs and Follett 1948 field notes), which is approximately 139 shoreline miles south of Elkhorn Slough. Yet, in the derby catches this common shark was also conspicuously absent.

Apparently Elkhorn Slough is the northern extreme of range for the guitarfish, as this species does not occur in San Francisco Bay. Although the range of the guitarfish is often given as San Francisco southward, Mr. W. I. Follett tells us that he does not have an authentic record of any specimens north of Monterey Bay.

It should be noted that the largest bat stingray caught at the Elkhorn Slough Derby weighed 85 pounds. There were several others approaching this weight. Contrasted with this are the smaller weights of the bat stingrays taken during three of the derbies held at Coyote Point in south San

Francisco Bay. During the 1948, 1949, and 1950 derbies the largest specimens caught weighed 40, 58, and 45 pounds respectively. In 1950 this was based on a total catch of 89 bat stingrays. The difference in weights in the bat stingrays from the two localities is quite remarkable. Whether this is caused by temperature and depth differences or whether it is due in San Francisco Bay to large bat stingrays not taking the hook (suggested by some experienced fishermen), remains to be determined. Certainly none of these weights approaches the 150-pound maximum reported for this species.

Data on the Elkhorn Slough Shark Derby were taken by the junior author assisted by Mr. Albert Razum.—*Earl S. Herald and Robert P. Dempster, Steinhart Aquarium, California Academy of Sciences, San Francisco, August, 1951.*

GOLDEN DOVER SOLE TAKEN AT EUREKA

A Dover sole (*Microstomus pacificus*) having the eyed side bright golden color was recently taken by the drag boat MacArthur of the Eureka trawler fleet. Through the courtesy of the skipper, Glenn Alley, and Ray Hamblock, manager of the Balestrieri Fish Company, this fish was turned over to the Marine Fisheries Laboratory at Eureka.

The color of a Dover's ocular side is usually a uniform light brown, occasionally with lighter or darker blotches. The upper side of this specimen was almost a complete uniform bright gold. The shoulder area had a small dark blotch as did the tip of the pectoral and caudal fins. Posteriorally at the base of the dorsal and anal fins were a few small dark blotches. Norman (1934, A Systematic Monograph of the Flatfishes) refers to this golden coloration as "xanthoeroism"— a condition in which only the orange and red pigments develop. Norman found this condition rare among flatfishes.

This fish was taken on July 27, 1951, in 80 to 85 fathoms northwest of Trinidad off Redding Rock. The total length was 558 mm. and the weight was 3.2 pounds. The specimen was a female with ovaries in a dormant condition.— *Ralph B. McCormick and Wayne J. Baldwin, Bureau of Marine Fisheries, California Department of Fish and Game, August, 1951.*

PACKAGED "SILVER SMELT"

During the summer of 1951, many tons of smelt were packaged at several plants along the Northern California coast for freezing and sale in the fresh fish trade. Catches were made at various places, but primarily in the vicinity of the mouths of the Noyo and Russian Rivers. These fishes, variously called surf smelt, whitebait or night fish, are true smelts with a small adipose dorsal fin, members of the family Osmeridae. The species was not determined. The fish were caught in the surf on sandy beaches during the spawning run. The net used was a copy of the Indian gear— a triangular dip net about seven feet on a side. The smelts were beheaded, intestines removed and the fish were packed in flat, oblong, waxed paper, one pound containers that looked like butter cartons. Stamped on the box was the pleasing name "silver smelt." The packaging of smelts is said to have been given an impetus in 1950 when the smelt run of

Washington was less than normal. The pack was said to have been in demand and found ready sale in the markets.

REFERENCES

Aplin, J. A.
1949. Whitebait. Calif. Div. Fish and Game, Fish Bull. 74, p. 142-144.

Bonnot, Paul
1930. The California whitebait fishery. Calif. Fish and Game, vol. 16, no. 2, p. 130-136.

—*W. L. Scofield, Bureau of Marine Fisheries, California Department of Fish and Game, August, 1951.*

IN MEMORIAM

PAUL BONNOT

Paul Bonnot died very suddenly on August 1, 1951, at Bodega Bay. At the time, Mr. Bonnot was engaged in an abalone survey of the Northern California coast, and had recently commissioned a fully-equipped diving boat with which he was pursuing the study.

Following graduation from Stanford University in 1923, Mr. Bonnot first joined the Fish and Game Commission in 1925 as a warden. He soon transferred to biological work and followed this field as a marine biologist for the Bureau of Marine Fisheries until the time of his death.

Mr. Bonnot's active career was noteworthy for the variety of subjects encompassed. His research on oysters led directly to the development of the oyster industry of Morro, Drakes, Tomales, and other California bays. His most intensive work was on the abalone fishery, and most of our knowledge of this valuable mollusk has come from his research. In the course of the abalone work, Paul probably did more deep sea diving than any other biologist. The extent of his other shellfish work is reflected in numerous publications on shrimps, clams, and mussels. He also conducted research on marine algae, which included underwater observations of the agar resource.

It seems a far cry from shellfish to marine mammals, but Mr. Bonnot was also an authority on sea lions and seals. His research in this field included numerous counts of the animals on the rookeries. During an aerial census several years ago, a Navy blimp crashed at sea and Paul and his companions spent over an hour in the icy waters off Cape Mendocino before their rescue by the lightship crew.

Paul's enthusiastic attitude toward his work was expressed in a conversation with his wife a few weeks before his death, when he said, "If I had my life to live over again, I would choose exactly the job I have."

The sincere sympathies of all who shared Paul's work on behalf of California's fish and game resources are extended to Mrs. Bonnot and his family.—*Richard S. Croker, Chief, Bureau of Marine Fisheries.*

REVIEWS

Water—Or Your Life

By Arthur H. Carhart; J. B. Lippincott Company, Philadelphia and New York, 1951; 312 p. $3.50.

WATER—OR YOUR LIFE is one of the most revealing books on the subject of use and misuse of water that has come to the attention of those interested in conservation of our natural resources. Mr. Carhart has focused attention in a most forceful manner on the quantities of water available for use by humanity in America and on the present rate of consumption of our ground-water stores which have been considered as unlimited heretofore but which are receding at an alarming rate from our underground storage reservoirs. This is a book that should be read by all who are interested in the use and conservation of this indispensable resource.

In the foreword written by Jay N. Darling, high tribute is paid the author for the manner in which he has handled the data resulting from his research on the subject. He states, "With commendable restraint and tolerant recognition of the conflicting interests involved, the author has brought together an amazing assemblage of factors from right under our noses and interpreted them in terms of their mass impact on our individual welfare and continental prosperity."

The chapter headings are interesting and intriguing and make the reader want to begin to read the book immediately. Early in the book the author shows the reader that our water resources are not inexhaustible and calls attention to what happened to ancient culture in Arizona as a result of the disappearance of water. He further discusses results of overuse and misuse of water in other parts of the world and shows from examples of inadequate planning in China that a nation cannot long live without water.

In a fascinating chapter entitled "Your Life Depends on It," the author presents a picture of the manifold uses of water for human need and the enormous quantities necessary to take care of the bare requirements of life. He points out that the individual share of water for each person on a national average basis is between 900 and 1,300 gallons per day per person. With an estimated population of well over 150,000,000 people the amount of water consumed by humanity in America is astounding. In another interesting chapter entitled "Our Daily Bread," the author discusses the quantity of water needed merely to produce the food which comes to our tables to sustain us. The figures run into billions on billions of gallons.

Most of our large industries use water pumped from wells rather than surface supplies because nature has all ready filtered, cooled, and stored well water in underground reservoirs free from contaminating influences that beset most rivers and ponds, but the rate at which ground water is withdrawn from these reservoirs is causing alarm in many places.

Of particular interest is the section of the book devoted to reclamation and flood control schemes planned by engineers of the two large federal agencies involved. In discussing the value of water to us, three nondestructive uses are listed: 1, water power; 2, navigation; 3, recreation. The author states, "Water power is important, so is navigation, and recreation is fundamental to maintaining individual and community stamina and soul. In a broad sense, all these nondestructive uses can fit in with other demands without too much downright conflict because they do not destroy water. But they must be planned for, their value must be recognized, particularly in recreational use, and only then, if we do such planning and fitting-together, can we hope to secure the fullest return from the water wealth we have."

The book is well filled with statistical information but is never dull reading. In fact, one's interest is so concentrated on the subject matter that it is disappointing when the final chapter closes. I unreservedly commend the book to all conservationists, regardless of their special resource interest, and to all citizens who are interested in the continuing welfare of our country.—*Harry A. Hanson, California Department of Fish and Game.*

Guide to the John Muir Trail and the High Sierra Region

By Walter A. Starr, Jr.; The Sierra Club, San Francisco, 1951; xii + 130 p. $2 (paper); $2.75 (cloth). 4th Edition.

Whether you are a devout lover of the High Sierra wilderness bent on probing "the countless half-told secrets of the rocks and trees and myriad unexplored aspects of the ever-changing scene," or merely an occasional vacationer in the high country, you'll want—and need—the new, fourth edition of "Starr's Guide."

This compact knapsack volume is still the best comprehensive guide to High Sierra trails. The plan of the book is similar to previous editions, but considerable new material has been added, parts have been rewritten, and the whole has been altered to include more information per portage-ounce.

The new edition contains a brief history of the origin of the John Muir Trail. The key to trail descriptions and map references has been expanded. Parts of the introduction on roads and approaches, advice to travelers, and maps and information have been revised. Trail mileages and distances have been corrected and additional routes and points of interest have been included. Many place descriptions have been rewritten and now include more notes on locations for camping and grazing.

Finally, the strip map showing Starr's "chain of blue lakes," the Muir Trail, and its approaches and laterals has been redone with many new knapsack routes added for the enthusiastic trail traveler.

The new "Starr's Guide" is not just a pocket volume, but a lifetime key to treasures of the High Sierra region.—*Elden H. Vestal, California Department of Fish and Game.*

Fisherman's Spring

By Roderick Haig-Brown; William Morrow and Company, New York, 1951; 222 p.; $3. Illustrated by Louis Darling.

No one has captured—the reviewer drops his guard and adds—perhaps no one ever will capture the spirit of the northwestern streams as well as Roderick Haig-Brown. In "Return to the River," "The Western Angler," and especially in "A River Never Sleeps," the angler-reader feels the push of the current against his waders, the slip of the gravel beneath his feet, and experiences the sudden, solid strike of a steelhead at the end of a long line. He watches the osprey high in the sky, follows the beat of mergansers up the canyon, and hears the chatter of the kingfisher. Most of all he feels the pulse and change of the seasons and the complexity of the underwater life. What then of Haig-Brown's newest book—this collection of essays or sketches? Does it fulfill the promise of his earlier ones? The author, himself, says: "In starting a new fishing book I have an uneasy feeling that I ought to protect myself with some . . . graceful apology . . . I have already written a lot about fish and fishing, and perhaps I have nothing new to say." And perhaps both the reviewer and the author agree here, for occasionally I thought, "This, I have read before." To me the writing lacks the freshness of his earlier books. The chapters seem slighter, with less substance; a few will appeal to only a limited audience: they are too personalized. Still, who can tell what the effect will be upon a new reader? I think that parts of the book will captivate him and so turn him, to his complete benefit, to the earlier books. As for those readers whom the author has already won, they can be reassured that he is still writing "what is in him and of him" and that should suffice. Haig-Brown's book will appeal to the technical angler as well as to the contemplative lover of nature. His knowledge of fisheries biology is both sound and invested with feeling. His ideals of sport and conservation are high. I wish that all sportsmen would read such chapters as "Putting Fish Back" and "Fishing and the Common Man."—*Wm. A. Dill, California Department of Fish and Game.*

Flowers of the Southwest Desert

By Natt N. Dodge, drawings by Jeanne R. Janish; Southwestern Monuments Association, Santa Fe, New Mexico, 1951, 112 p. $1 (paper).

"Flowers of the Southwest Desert" is a handbook of the common flowering plants of the deserts of Southwestern United States and Northwestern Mexico. Specifically, the following areas are covered: the Chihuahuan, the Sonoran, and the Mohave-Colorado deserts. The booklet has a twofold purpose, (1) to aid the layman in identifying desert flowers, and (2) to give some background material about each of the various plants listed.

Two methods are used in the identification of desert flowers: (1) the plants are grouped according to the color of their flowers, and (2) there are detailed drawings of each plant. The author acknowledges the inherent weakness of a color key in identifying wildflowers, but, as explained by him, success in using the booklet depends upon one's becoming accustomed to it. In several field trials made by the reviewer near the Salton Sea, California, the color key did prove to be a minor stumbling block; however, after a few trials, one soon overcomes this obstacle. The drawings are excellent, an important factor, since identifications depend upon them. Many drawings include minute details, such as shapes of leaves and fruits, arrangements of hairs on stems and leaves, cross-sections of stems, etc. These details often appear when most needed in making determinations. The sketches showing the size of the plants relative to an average man are of help also.

The background material is brief but contains a wealth of information. Included are such items as the origin of the plant names, the use of the plants by wild and domestic animals, and the use by human inhabitants, past and present. This type of information adds immeasurably to the booklet's value as a field guide. In addition to making the booklet more interesting, the information is easier to remember.

The occasional visitor to desert regions will find his trips enriched by the use of this booklet. On the other hand, the serious botanist will find it all too brief.—*Leo Pinkas, California Department of Fish and Game.*

American Wildlife and Plants

By Alexander C. Martin, Herbert S. Zim and Arnold L. Nelson; McGraw-Hill Book Co., Inc., New York, 1951; ix + 500 p., $7.50.

This book is a guide to wildlife food habits in the United States, bringing together a summary of the large fund of food habits data collected by the Fish and Wildlife Service plus data from other workers.

The book is divided into three parts. Part one is of an introductory nature and discusses in general terms the relationships of animals to plants, gives methods of collecting and analyzing food habits materials and explains how to interpret the data presented in the text. Part two is concerned primarily with birds and mammals and the foods which they consume. Nine categories or major units of animals are listed and each is treated as a separate chapter under the following titles: waterbirds; marsh birds and shorebirds; upland gamebirds; songbirds; birds of prey; fur and game mammals; small mammals; hoofed browsers; and fish, amphibians and reptiles. Under these categories the species are taken up individually. For each species the following data are given: the range, shown on an outline map; life history notes; an animal-plant food ratio diagram giving at a glance the percentage of plant and animal food in the diet by season of the year; brief notes on any animal food that may be taken; and a list of the important plant foods in the diet. The plant foods are given a rating as to importance; also noted is the season of the year when each is eaten, the section of the United States where each is important and the number of analyses upon which the summaries are based. Part three deals with the plants which are useful to wildlife. The plants are grouped into four major categories as follows: woody plants; upland weeds and herbs; marsh and aquatic plants; and cultivated plants. Under these categories the main genera are taken up individually. Information on the genera includes an outline map showing distribution, notes on distribution, parts eaten, and a list of animals which feed on the plants with a rating of their importance to each animal.

The food habits of birds of prey and predatory mammals are but briefly treated as this book deals mainly with plants in relation to animals. Also, the section on fish, amphibians and reptiles is sketchy.

The book is to be recommended as a reference for game managers and technicians. Further, it is written in a style which can be readily understood by sportsmen, farmers and others who may have an interest in wildlife food habits. However, technical workers in the wildlife field will find the information presented to be rather generalized, for the subject is complex and precludes detailed treatment in any one book. Research into local problems of food habits is still desirable.—*Carol M. Ferrel, California Department of Fish and Game.*

Practice of Wildlife Conservation

By Leonard W. Wing; John Wiley and Sons, Inc., New York, 1951; viii + 412 p.; 40 photographs, 21 figures. $5.50.

This is a general textbook covering the broad field of wildlife conservation and management. The contents include 24 chapters, among them the following: Techniques of Field Investigations and Practices, Farm Game and Its Management, Forests and Forest Wildlife Management, Forest Game Mammal Management, Game Management in the Open Range, Northland Wildlife, Fur Bearer Management, Wildfowl Management, Stream Improvement and Management, State Powers and Controls, Federal Wildlife Controls in the United States, and Administration and Regulation. A helpful selected reading list is given at the end of each chapter, and there is as well a very complete index.

This book, though primarily prepared for students at the college level, is also a good handbook for the field man. Dr. Wing endeavors to blend the theoretical and scientific aspects of conservation with actual field practice that experience has shown to be desirable and workable. The biology of wildlife is integrated with management practices and therefore gives the reader a broad outlook in the field of wildlife conservation.

Some wildlife technicians, however, may find it hard to support Dr. Wing's conclusions on many of the subjects discussed. To cite one example, he does not include California as a state where the ring-necked pheasant has been successfully introduced. And some of the causes or results of wildlife problems are presented with definite conclusions, seemingly without recognizing the possibility that one problem may not have the same cause or solution in all parts of America.—*John B. Cowan, California Department of Fish and Game.*

REPORTS

FISH CASES

July, August, September, 1951

Offense	Number of arrests	Fines imposed	Jail sentences (days)
Abalone: Overlimit; out of shell; undersize; failure to show; no license; closed season	91	$2,482.00	-----
Angling: No license; using another's license; failure to show license; false information on license application; predating license; no noncitizen license; nonresident purchasing resident license; closed waters; 2 poles; 3 poles; too near dam; night fishing; set lines; more than 2 attractor blades; possessing spear within 300 feet of stream	388	7,413.00	15
Barracuda: Selling fish taken on sport boat	1	50.00	-----
Bass: Closed season; taking with net, with 2 poles, in refuge; overlimit; night fishing; undersized; failure to show fish; no license; wastage; possessing for sale in restaurant	180	5,942.00	4
Catfish: Undersized	2	35.00	-----
Carp: No license	2	50.00	-----
Clams: Closed season; overlimit; no license; undersized; digging during illegal hours; night digging; taking in state preserve; taking and selling undersized; failure to show license	67	1,665.00	151½
Commercial: No commercial license; overlimit frogs, abalone; possession and sale undersized crabs, salmon, catfish, white sea bass; sale of undersized tuna and skipjack; illegal use of round hand net, trawl net; selling untagged trout, catfish without dealer's license and without making receipts; failure to keep boat records, to register boat; operating salmon troll boat without landing net or scoop; lobsters, closed season; abalones out of shell; dealer allowing sardines to deteriorate	97	6,442.50	
Crab: Possessing live crabs, closed season	1	200.00	--
Frog: Shooting at night; undersized; taking at night	2	75.00	
Grunion: Closed season	2	30.00	----
Lobster: Closed season	4	100.00	
Pollution: Oil; continuous oil pollution; pumping oil into water; beet sugar residue	7	1,300.00	--
Salmon: Overlimit; taking with gaff, at night, 2 rods; possessing gaff within 300 feet of river	8	325.00	--
Sunfish: Overlimit; closed season; taking with net in District 2	15	437.00	-----
Trout: Overlimit; 2 rods; failing to show on demand; taking in closed waters, by means other than angling, with net; failing to declare fish taken outside State; no license; using 2 poles; blocking trout stream with pump without permit	48	1,464.00	10
Sale of seized fish	----------	3,244.24	----------
Totals	915	$31,254.74	180½

GAME CASES

July, August, September, 1951

Offense	Number of arrests	Fines imposed	Jail sentences (days)
Antelope: Taking female	1	$100.00	----------
Deer: Taking fawn, spike buck, doe, doe at night, doe by spotlight, forked horn by nonresident using resident license; possession of fawn, of gun and deer in refuge, of artificial light while hunting, of another's tags; failure to tag, to retain hide and antlers; no tags in possession; mutilating tags; hunting at night, with .22 rifle, without license, in refuge; shooting from car; closed season; allowing dogs to chase, closed season; stealing deer; picking up fawn	172	18,009.00	557½
Deer meat: Possessing unstamped meat, portions of doe, illegal meat, in closed season; transporting in closed season	41	4,600.00	225
Dove: Closed season; alien shooting without license; illegal possession; shooting from car, after sunset, with unplugged gun	84	3,050.00	----------
Duck: Closed season; late shooting; illegal possession	7	275.00	----------
Goose: Illegal possession	1	25.00	----------
Hunting: Shooting from motor vehicle; hunting without license; gun in refuge; unplugged shotgun; false statement in securing license; night hunting; possessing gun, spotlight; using artificial light; loaded gun in car; shooting from public road; failing to show license	66	2,505.00	300
Nongame birds: Killing blue heron	1	25.00	----------
Pheasant: Taking hen; closed season; no license; hunting with .22 rifle; raising pheasant without breeder's license; taking from auto; hunting in closed cooperative area	45	3,507.00	40
Quail: Closed season; no license; illegal possession	6	310.00	25
Rabbit: Taking after hours; closed season; no license; shooting from road; night hunting; failing to show; shooting from auto; spotlighting; unplugged shotgun	66	1,990.00	----------
Sage hen: Closed season	4	500.00	----------
Totals	494	$34,896.00	1,147

SEIZURES OF FISH AND GAME

July, August, September, 1951

	Number	Pounds
Fish:		
Abalone	1,055	----------
Barracuda	----------	209
Bass	830	3
Carp	----------	50
Catfish	621	6
Clam	2,637	----------
Crab	59	----------
Frog	234	----------
Grunion	21	----------
Lobster	20	1,075
Perch	14	----------
Rockfish	16	----------
Salmon	66	----------
Sardine	----------	3,359
Sunfish	710	----------
Trout	455	----------
Tuna	----------	12,662
Game:		
Antelope	1	----------
Deer	89	367
Dove	258	----------
Duck	5	----------
Goose	1	----------
Heron, Blue	1	----------
Pheasant	124	----------
Quail	13	----------
Rabbit	97	----------
Sage Hen	12	----------

ERRATUM

"A Preliminary Analysis of Northern California Salmon and Steelhead Runs," vol. 37, no. 4. On page 505 on the fourth line under "Discussion," read "density-independent" for "density-dependent."

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Notice is hereby given that the Fish and Game Commission shall meet on January 4, 1952, in the State Building, San Francisco, California, to receive recommendations from its own officers and employees, from public agencies, from organizations of private citizens, and from any interested party as to what, if any, orders should be made relating to fish, mollusks, crustaceans, amphibia, reptiles, birds, and mammals or any species or variety thereof.

Notice is hereby given that the Fish and Game Commission shall meet on January 25, 1952, in the California State Building, Los Angeles, to hear and consider any objections to its determinations and proposed orders in accordance with Section 14.2 of the Fish and Game Code, such determinations and orders resulting from hearing held on January 4, 1952.